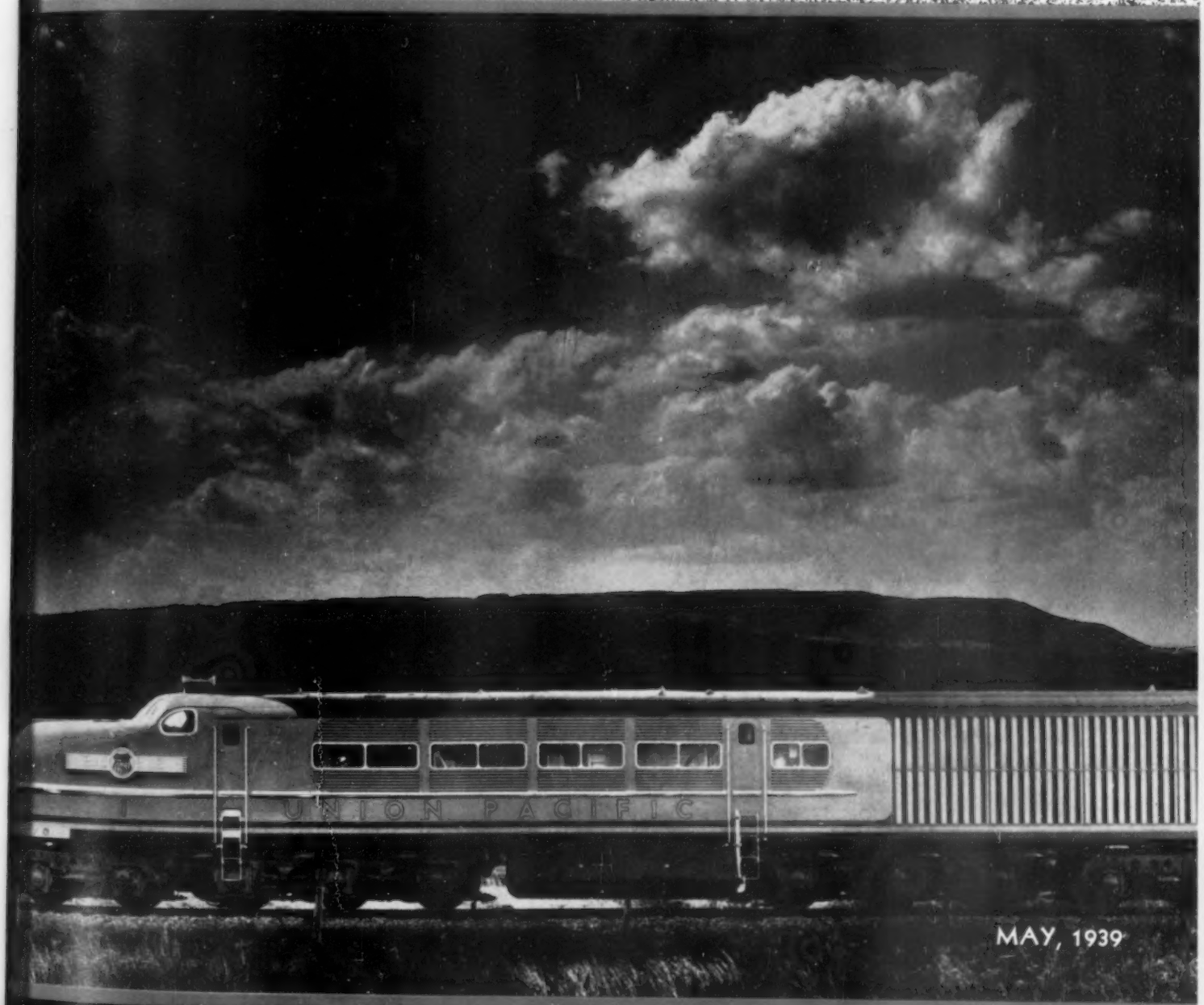
The Welding Journal



MAY, 1939

The Journal of the American Welding Society

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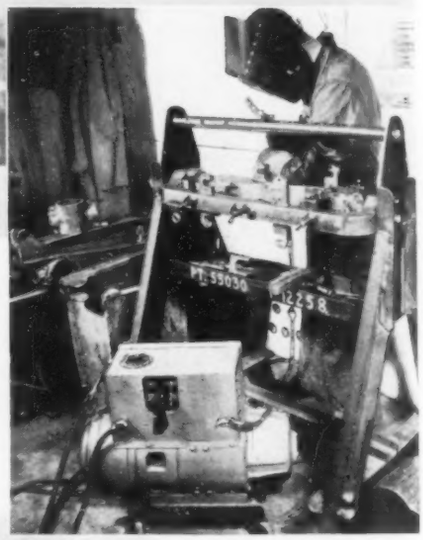

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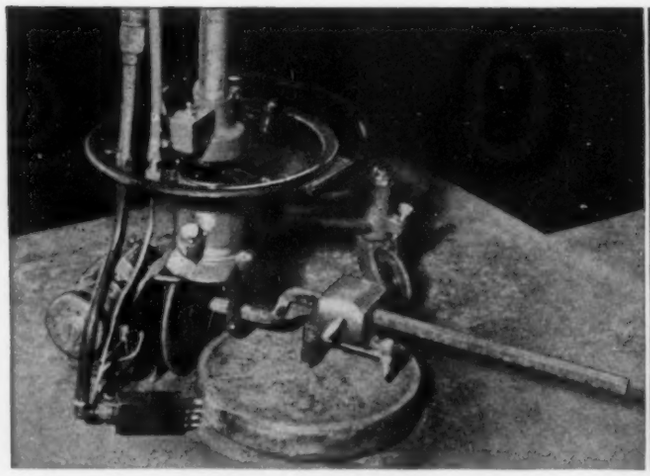
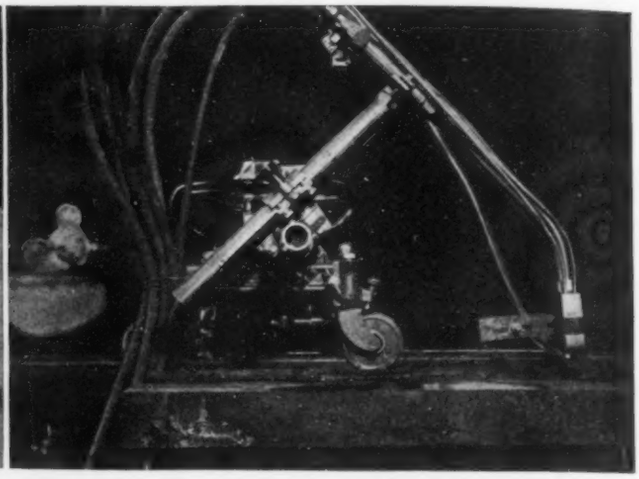
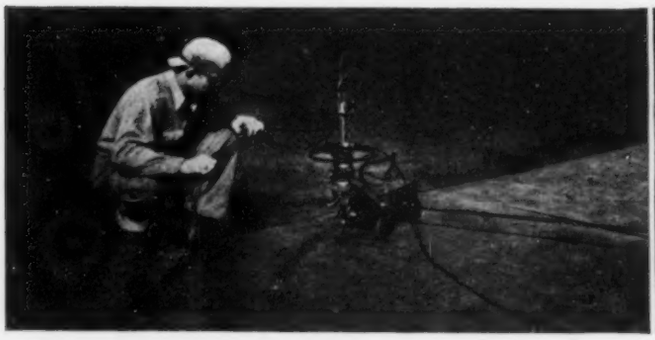
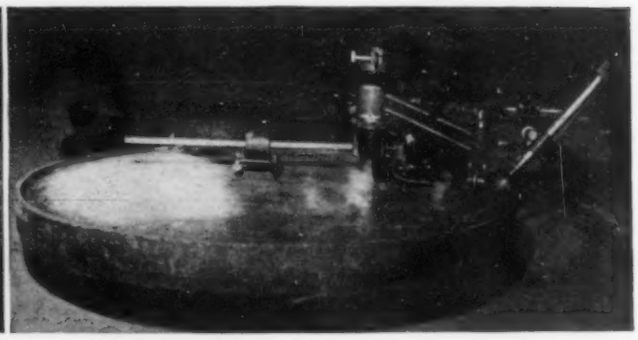




The CM-16 is easily adaptable to flame-hardening and flame-softening. A flame-cut gear blank (left) is being softened to make machining easier. The flame-hardening setup (right) is used to harden machine parts so they will last longer.



Storage tank heads, sheets, and bottoms can be economically cut with the CM-16. This large steel plate is being shaped for a tank bottom.



Here the CM-16, equipped with heavy cutting attachment, is beveling the edge of a head for a gas storage tank preparatory to welding.

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Welding Journal

VOLUME 18, No. 5 MAY 1939

MODERN METHODS AND MODERN Steels in Welded Ship Constructions*

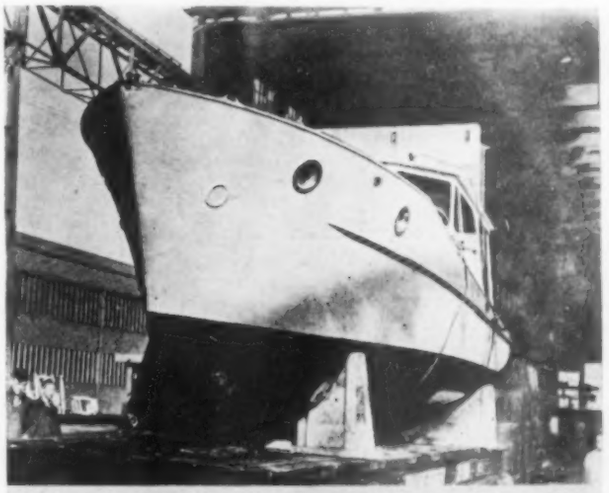
By DR. P. SCHOENMAKER† and IR. G. DEROOY‡

WHEN we trace the history of welding applied to shipbuilding, we find, that next to an ever increasing application in the construction of smaller and larger parts, foundations etc., the buildings of all-welded ships, at least as far as deep sea vessels are concerned, has generally speaking been limited to smaller tankers, coasting vessels and yachts of which the "Fullager" built in 1920 and claimed to be the first all-welded sea going vessel, is a well known example, has clearly proved the advantages and reliability of electric welding. Notwithstanding that this vessel was thrown on the rocks and had to struggle with very bad weather, the hull remained in an excellent condition. Since that time. electric welding has steadily been more and more developed and researches have been made to discover construction methods, which are especially suitable for welding.

Universal endeavors to arrive at lighter constructions have brought to the fore a desire to produce a construction steel with a higher yield point and tensile strength and yet sufficient ductility to replace the up till now customary mild steel St. 37. After many years of study and research, the steel works at last succeeded in manufacturing such a steel with a yield point of about 52,000–57,000 lb./in.^{2} and a tensile strength of 74,000–88,000 lb./in.^{2} and which since 1910 has been used in the construction of bridges and in ship-building. The saving in weight, which may be obtained through the use of such steels, is especially in naval construction, where every reduction of weight means an increase in armour plating and armament, of the utmost concern and the application thereof most important.

Experience gained in previous years with welding of high tensile steels, has taught us that when properly applied very favorable results may be obtained. This is the reason that it has become desirable to weld also primary construction elements, even those subject to the highest stresses.

Fig. 1—The Completed Yacht



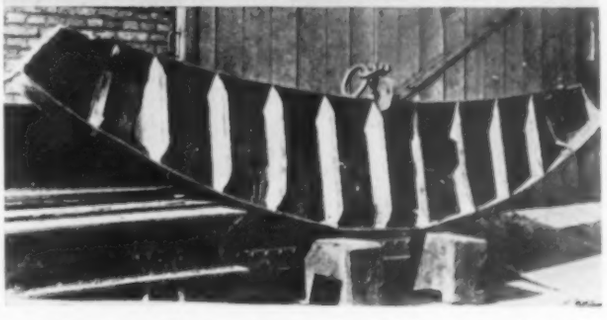


Fig. 2—All Oil and Water-Tight Floor-Timbers in the Double Bottom Are Also Entirely Electrically Welded; This Welding Is All Done in the Workshop

ELECTRIC WELDING OF HIGH TENSILE STEELS

Electric welding of the usual mild steel qualities no longer offers a single difficulty and the joints, provided they have been made with coated electrodes of good quality, are of such homogeneity and tightness that perfect security can be guaranteed.

On the other hand, when welding high tensile steels many difficulties were at the beginning encountered and

* The authors of this paper received the first main award, $3764.94, in Watercraft classification of the $200,000 Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, in which savings of $1,600,000,000 were shown available to industry by wider application of arc welding. The original paper, of which this is a brief, contains approximately 27,000 words and 178 illustrations.

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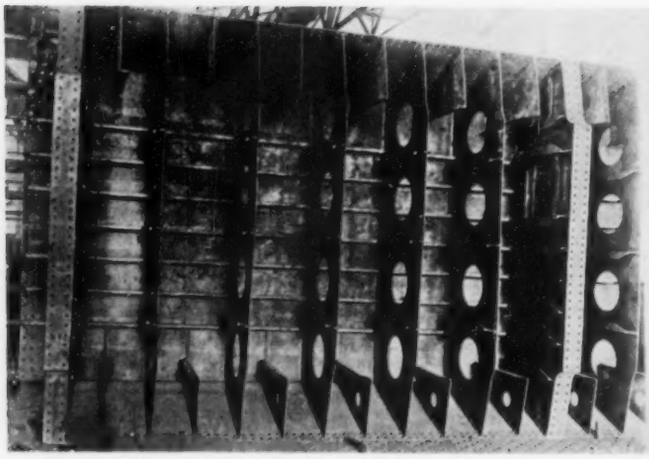


Fig. 3—Double Bottom Section Shows the Lower Edge of the Double Bottom Plating

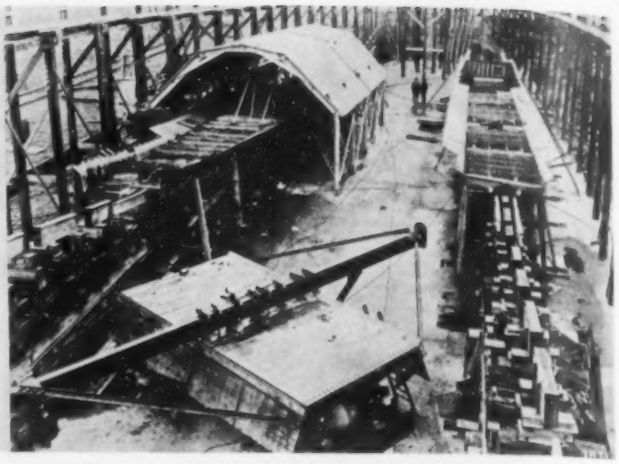


Fig. 4—These Sections Are Transported to the Slip-Way, and Attached to the Horizontal Keel Plate

only after profound researches and collaboration between consumers and manufacturers favorable results were at last obtained.

For the investigation of the mechanical characteristics of welds of high tensile steels and the eventual influence of the composition, a very extensive series of tests were taken with two kinds of steel, namely, a chromium-silicon-copper steel and a manganese-silicon-copper steel.

The investigations were made with the aid of the following tests: (1) Tensile test, (2) bending test, (3) impact test and (4) fatigue test.

These tests were taken with the non-welded plate material and with the welded joints. All specimen bars were taken from a $^1/_2$-inch plate; for the welded joints a V-weld of 90° was made.

The Tensile Test.—The tensile strength of the plate metal comes to approximately 80,000 lb./in.^{2} of the weld to 76,000 lb./in.^{2} and therefore answers amply to the requirements. Of great practical importance is, that the yield point of the material is practically equal to that of the weld metal.

The characteristics of the weld metal are determined on round test bars which were obtained through depositing in an angle bar so much metal till sufficient was present for machining the test bar. In this manner a tensile strength of 74,000 lb./in.^{2} for the weld metal was determined with an elongation of 28.4%.

The Bend Test.—The bend test shows the average angle which normally can be arrived at lies between 70 and 75°. In many cases however, if the plate material is of good and uniform quality, capable welders can obtain a bending angle of 180°.

The Impact Test.—The average value of the weld comes to 9–10.3 kgm./cm.^{2} and of the plate to 10–12 kgm./cm^2.

Fatigue Test.—When comparing however the values for the high tensile steels with that of the mild steels St. 37, it appears that the fatigue strength of the welded joints of high tensile steels lies considerably higher because of which the use of these steels for welded construction is certainly justified.

Construction Methods for Welded Ships.—In order to arrive at the greatest possible strength and to avoid as far as possible all difficulties, a number of special construction methods have during the last few years been developed. These will be briefly described hereunder.

The Trussweld System.—In this construction the rigidity is obtained by mutually welding angle steels in three perpendicular directions on the junction points. This method is used principally for tank lighters, pontoons, barges and ferries.

The Channel System.—By this method the hull consists out of connected U-scantlings.

The Reverse Channel System.—Also here the hull is built up out of U-scantlings but always turn and turn about. In this manner a larger moment of resistance at the same weight is obtained. On the other hand, the ship resistance is also greater and moreover, a larger quantity of welding material is used.

The Lock-Notch System.—By this method, longitudinal frames over which knee-shaped cross connections are welded, are used.

Transverse Frame System with Longitudinal Plating.—By this system, the hull construction is practically the same as the normal construction, i.e. transverse frames and fore and aft running plates. Often the longitudinal keelsons are welded to the floor timbers; both parts are then provided with notches.

Transverse Frame System with Transverse Plating.—As formally, difficulties were seen in the welding of longitudinal seams, the longitudinal plating for smaller vessels was replaced by transversal plating.

Spanner System.—According to this method, the frames are welded on separate small legs. This can be arrived at still more simply by a cut out scantling, which can be obtained by zigzag cutting of high I-beams.

Longitudinal Frame System and Longitudinal Plating.—Here the longitudinal frame method ("Isherwood" system) is used, while also the fore and aft shell plating is retained.

Pannel System.—By this method, of Dutch origin, the hull is reinforced by longitudinal and transversal frames. The cross frames are notched in which the lighter longitudinal frames are welded.

Hull Flange System.—This system is also of Dutch origin. By this construction the hull is made out of a number of relatively small shell-strakes of which every other one is of constant width. Both longitudinal edges of these strakes are flanged in such a way that the strakes of constant width get an elevated flange and that the intermediate of width deviating strakes, are provided with a lower flange.

In the beginning of 1938 a motor yacht of 8.70 x 2.44 m. was entirely welded according to this system. The completed yacht is illustrated in Fig. 1.

WELDED JOINTS IN SHIPBUILDING

The welding connections which in external constructions generally are used, are as follows:

I. *Butt-Joints.*—This is the most generally applied and used up to a plate thickness of about $^3/_4$ in.

II. *Fillet Welds.*—It goes without saying that these weldings often occur by all perpendicular connections.

III. *T-Joints.*—These joints are applied mostly by connections with normal static stresses.

APPLICATION OF WELDING OF HIGH TENSILE STEEL IN NAVAL CONSTRUCTION FROM 1937 UNTIL NOW

When we compare the application of the welding process by a submarine construction in 1933 with that of today, it becomes very clear that in this period important developments in welding of high tensile steels has taken place and which is demonstrated in: (1) Greater diving depth to more than 100 m., and (2) in heavier armaments.

In order to properly grasp the importance of the welding process it is also desirable to examine the construction of a submarine.

Such a ship consists of a cylindrical part which has to absorb the underwater pressure. Around these cylinders there are tanks which by means of large valves placed underneath can be filled quickly, whereby the buoyancy of the ship is destroyed and with the aid of propellers and rudders she then can dive and continue to proceed submerged. The outside of these side tanks consists out of a shell-plating which may be thin, because apart from very exceptional circumstances—the water pressure on both sides of this outside hull is equal as the kingstones remain open. By means of large air exhaust valves on top of these side tanks a quick filling up is aided as much as possible.

The cylindrical pressure body is cut off underneath by the double bottom plating under which the various oil and water-tanks are situated.

In many submarines, the double hull-system at the ends of the boat goes over to the single hull-construction, as otherwise the two hulls would come too close to each other, which not only would be difficult to construct but would also be hard to conserve. At the ends, therefore, we get a pressure-body of which the section is no longer cylindrical but more closely resembles the ordinary ship shape. The consequences are that the fore and aft frames are heavily stressed on bending and therefore must be strongly constructed.

In the double bottom and in the horizontal keelplate the butt joints are entirely welded. These seams have been welded partly in the workshop and partly on board. All oil and water-tight floor-timbers (Fig. 2) in the double bottom are also entirely electrically welded; this welding is all done in the workshop. In Fig. 3 a double bottom section is reproduced which shows the lower edge of the double bottom plating. These sections are transported to the slip-way (Fig. 4), and attached to the horizontal keelplate.

In the now-building submarine minelayers the connection of the horizontal keelplate to the first sheer-strake is entirely welded. These seams are entirely welded in the workshop.

The seams and butt joints in the compression cylinder were partly welded in the shop and partly on board. For this connection a V-joint with rewelding strip was used; the strip is only then added when the root of the V-weld is chipped away and rewelded.

A very difficult and therefore most interesting welding construction which has only been used lately, is that of the frames in the forecastle and after body of the ship. On account of the oval shape of the frames considerable bending moments occur. According to the required moment of resistance increases, the height of the frame becomes greater and of the inner buntlines heavier. Each of these frames is carefully calculated so that each section could be exactly determined.

Through welding a very considerable weight economy was obtained as hereby it became possible to bring the frame section in accordance with the occurring stresses with a consequent better division of material. When welding the frames, an additional complication arises because the outer flanges do not stand perpendicular on the body plate. The flange plate namely must follow entirely the bevel of the hull because of which it is necessary to let the body plate form an ever changing angle of deviation of 90° on different points and frames.

Many other important parts, like engine beds, gun foundations, water-tight bulkheads between inner and outer hull, the shaft-bossings and machine gun bores, the small ballast partitions on the horizontal keel-plate and the torpedo loading head, were all electrically welded. We might reiterate that all these parts are made of high tensile steel.

Figure 5 gives a birdseye view of the two submarine minelayers in February 1938.

ECONOMIES OBTAINED IN CONSEQUENCE OF THE WELDING PROCESS

The principal advantages of welding in regard to riveting, are the elimination of angle steels and overlapping.

This really is the gist of the savings which is obtained through electric welding, a saving in material which in the first place gives a considerable saving in weight next to a cost economy.

In smaller vessels where the flange percentage and the weight caused by overlapping are relatively high, this saving in weight will be greater than in ocean steamers. For all-welded small tanker about 130 feet long, the total saving in weight comes to about 30%, for a welded cargo-boat of 250 feet to about 12.5%. At the same time the

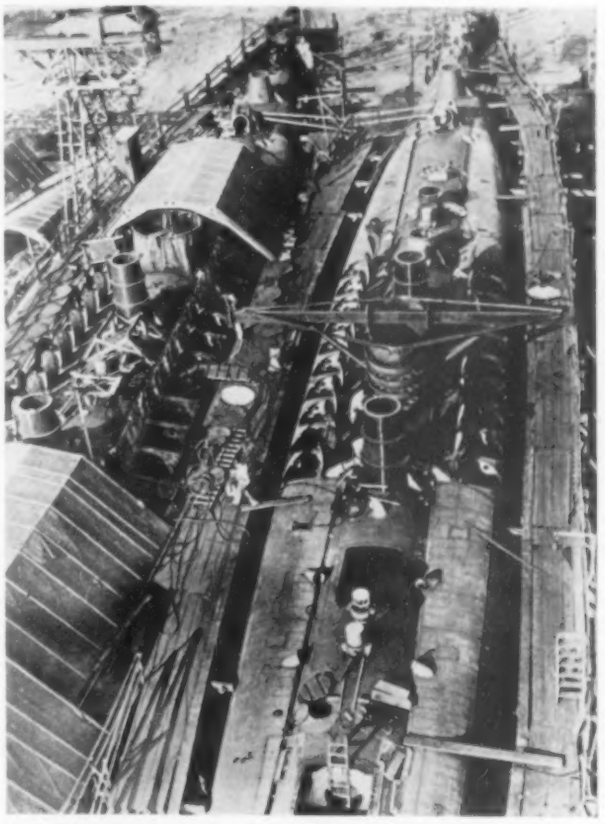


Fig. 5—Birdseye View of the Two Submarine Minelayers in February 1938

engine weight and fuel stock becomes smaller while the displacement decreases by some percentages.

Next to that it should be remembered, that also the indirect costs, which often form an important item, can be considerably decreased. In particular we draw attention to the much lower pressing costs, which by a double bottom sometimes show a saving of 30%.

Next to the cost of material, the wage costs also play an important rôle and it is interesting to see how the work and wage hours compare by riveting and welding jobs.

GENERAL ECONOMY AND ADVANTAGE OF WELDING OF HIGH TENSILE STEEL

1. *Commercial Shipbuilding.*—In order to get an idea of the advantages offered by the use of high tensile steel a check has been made of what economies are arrived at in the case of a ship where the welding process has already been extensively made use of if the various parts, of which in the first instance the principal structural constructions, therefore those which are entirely situated above or below, foundations, bulkheads, etc., are made of welded high tensile steel.

For a passenger steamer of 40,000-ton displacement, 1500 ton high tensile steel material can be used. In connection with the higher yield point a reduction of the scantlings of 20% is fully justified so that the replacing of mild steel by high tensile steel only, already gives a weight saving of 300 tons which can still be increased to 370 tons if the welding process is used. This means an extra increase of the dead weight capacity by ±2%, an advantage, that repeats itself at every trip and represents over the whole life of a ship of from 15 to 20 years a considerable amount. Even if the price of high tensile steel is higher and the cost of welding, because of stricter examination with X-rays for instance, somewhat greater than by riveting, the use of a welded high tensile steel construction will show a financial advantage as the greater dead weight capacity, if perhaps, not directly certain after one or two years, will yield favorable financial results.

It is also possible to let the ship keep her same dead weight capacity, so that the displacement can become ±1% smaller. This means for the service speed a saving in power of at least 300 hp. which will show a yearly saving in fuel of Fl. 18,000—($10,000).

To this must still be added the savings in costs consequent on the lower harbor and piloting fees because of the smaller displacement and therefore smaller tonnage.

2. *Naval Construction.*—In war ships, cruisers, torpedo destroyers and submarines where the question of costs plays a much minor rôle than by the mercantile marine, is the weight and space saving on the other hand the most important factor. If, therefore, the use of the welded high tensile steel construction in commercial shipbuilding still is limited, in naval building this process is already more and more applied and was extensively used in the building of the submarines in 1938.

The weight economies obtained through welding of the hull the double bottom, the water-tight bulkheads, the foundations and numerous other parts and through the use of high tensile steel, means for a submarine of about 1000-ton surface displacement a weight decrease of certainly 65 tons, whereby the fuel stock and armaments can be considerably enlarged. If for some reason or other this is not possible or required, the saving in weight can be used to increase the ballast whereby for a ship of the above mentioned dimensions the metracentric height could be increased by no less than 4 inches.

The great advantage of the use of high tensile steel becomes still more striking, when we see that by not increasing the dimensions in regard to those of mild steel but by keeping them equal, the diving depth for a boat of 1000-ton surface displacement can increase by certainly not less than from 30 to 40%.

When these economies are divided over divers factors, the results would be that the ship mentioned could benefit by the following improvements.

1. 50 feet greater diving depth (15 tons)
2. 2 inches greater metracentric height (20 tons)
3. More ammunition and torpedos (5 tons)
4. Heavier anti-aircraft guns (4 tons)
5. Larger diesel engines, therefore greater surface speed (8 tons)
6. A larger storage battery, therefore greater submerged speed (9 tons)
7. More fuel and lubricating oil, therefore greater operating radius (4 tons).

These savings in weight can naturally be divided differently or applied to one or two of the above mentioned improvements, but this division is given in order to obtain an impression as to which advantages the applications of electric welding and high tensile steel can produce.

Part of the savings can also be sacrificed in order to increase the safety coefficiency of the compression strength of the hull, so that the official diving depth can in case of distress be exceeded to a greater extent than formerly, when the hull was made of riveted mild steel.

By torpedo destroyers the weight savings obtained will be largely utilized to increase the speed and radius of action. Although for these ships high tensile steel has been used for a considerable time, the application of electric welding gives at least a saving in weight of about 3% of the displacement or 45 tons. The armament, engine equipment or fuel stock can to this extent be increased or the speed further augmented.

Economy of Welding and the Use of High Tensile Steel

	Welding Against Riveting		Welded High Tensile Steel Against Riveted Mild Steel	
Constructional Part	Saving in Weight	Saving in Cost	Saving in Weight	Saving in Cost
Shell and deckplating	9 %	8 %	20.8 %	8.3 %
Double bottom	23.5 "	20.2 "	33.3 "	7.0 "
Flat bulkheads	18.0 "	12.3 "	34.5 "	9.5 "
Concave bulkheads	8.6 "	3.6 "	32.8 "	11.7 "
Engine foundation	15.9 "	12.7 "	32.7 "	2.5 "

It is clear that welding in comparison with riveting shows a remarkable saving in weight and cost, but in comparing welded high tensile steel with riveted mild steel, the weight economy is still more accentuated. The saving in cost however, because of the higher price of high tensile steel, is somewhat smaller.

The weight economies are not only of the greatest importance to commercial vessels but in the first place also to battleships and it may be expected that the application of the electric welding process itself and more especially the welding of high tensile steels shall in the near future develop more and more. The authors sincerely hope that also their study has contributed to this development.

WELDING FROM A SHIPBUILDER'S Viewpoint*

By B. A. RUSSELL†

GREAT strides have been made during the past few years in the improvement of design for, and in the use of, welding in shipbuilding.

Typical examples of the progress which has been made are to be found in the partly welded tankers constructed by the Federal Shipbuilding and Dry Dock Company at Kearny, New Jersey.

After having constructed seventeen (17) all-welded oil barges, deck scows and other miscellaneous welded work, and having utilized welding extensively on the Grace Line SANTA ships, our company decided to build, as stock ships, two 13,000 D.W.T. bulk oil tankers. We planned to use welding more extensively than had previously been attempted on large tankers. A vast amount of time and expense was spent in the study of the design, and the final result was gratifying to all concerned.

As a result of the development of this design, the bulk oil tankers S.S. "R.P. RESOR" and S.S. "T.C. McCOBB" were built in 1935–1936. These ships have the following dimensions and particulars:

Length O.A.	445 feet–0 inch
Length B.P.	435 " –0 "
Beam, molded	66 " –6 "
Depth, upper deck at side	34 " –6 "
Draft	28 " –1 "
Deadweight	12,900 tons
Bulk oil capacity	105,000 bbls.
Gross tonnage	7,452
Net tonnage	4,620
Steam turbine propulsion	3,000 SHP.
Steam pressure	400 lb./sq. in.

The two ships were built on the Isherwood Bracketless longitudinal system and were of the "Arc Form." Metallic arc welding was used in the construction of most of the internal structure in way of the cargo oil tank spaces as well as for many other parts, such as deck houses, main and auxiliary machinery foundations, deck fittings, and certain pipe lines.

These ships were such a departure from the usual type of construction that they created great interest in the shipbuilding and ship operating fields, and were the forerunners of our present welded and partially welded large bulk oil tonnage. The "RESOR" and "McCOB" were sold to the Standard Oil Company of New Jersey before completion, and following their delivery two more tankers of the same dimensions and particulars were laid down for the Pan American Petroleum and Transport Company, the S.S. "PAN MAINE" and S.S. "PAN FLORIDA." These ships were delivered in 1936.

Many old time ship operators were skeptical of welded construction due to their lack of knowledge on the subject, and also as the result of improper applications of welding in some of the earlier attempts. However, after many welded oil barges had been built and the operators found out what a saving there was in maintenance, with no leaky bulkhead rivets, and realized the increased earnings due to higher deadweight efficiency on account of weight saving, they became interested in the use of more welding on large ships.

In recent years acceptance of welding has been expedited by the action of the U. S. Navy Department in specifying welding for important structural members in new cruisers and destroyers. This action has further strengthened the confidence of the shipbuilder and shipowner in the reliability of welding.

Due to the enormous investment for fabricating and riveting equipment in existing shipyards, the transition from riveted to welded construction has presented serious financial problems and has proceeded in orderly fashion. The expense of providing each welder with proper equipment has been no small item.

The successful ship starts first with a proper design and this is where many of the earlier welded vessels have fallen short of the attainment of the efficiency possible; because the design started out by copying orthodox riveted construction, simply substituting welding in place of rivets, and therefore not making any appreciable saving in weight and only a slight increase in strength.

With welded construction on ships, all attachment angles, bulkhead boundary bars, clips, box corners and angle collars are eliminated along with costly anglesmith work. Plate laps are reduced in size or eliminated. The metal saved can be redistributed to give greater strength, relocated to compensate for corrosion or utilized to increase the carrying capacity of the ship.

A still further economy will be possible if demand in this country ever warrants the production of special rolled shapes for such use as the stiffening of panels, where now flanged plates and split "I" beams are required.

A properly designed or partially welded ship has a very appreciably saving in weight and therefore an increase in deadweight capacity, which is the item that counts most in the earning capacity of the ship. This item helps to decide whether the investment is economically sound.

The next important items are the methods used in assembly and erection, and most of all in the procedure used in the welding. Too great stress cannot be put on this last point as the study and adoption of appropriate procedure will save much trouble due to warping, locked up stresses and possibly cracked welds or plates. It is, of course, necessary that all welding be done by qualified welding operators certified by the American Bureau of Shipping. Good fitting up of all structural parts at time of assembly is very essential to reduce the amount of welding and provide proper strength. A maximum amount of the welding should be done in the shop or under cover, where the welder is protected from the weather, and the work should be arranged as far as possible for down-hand welding.

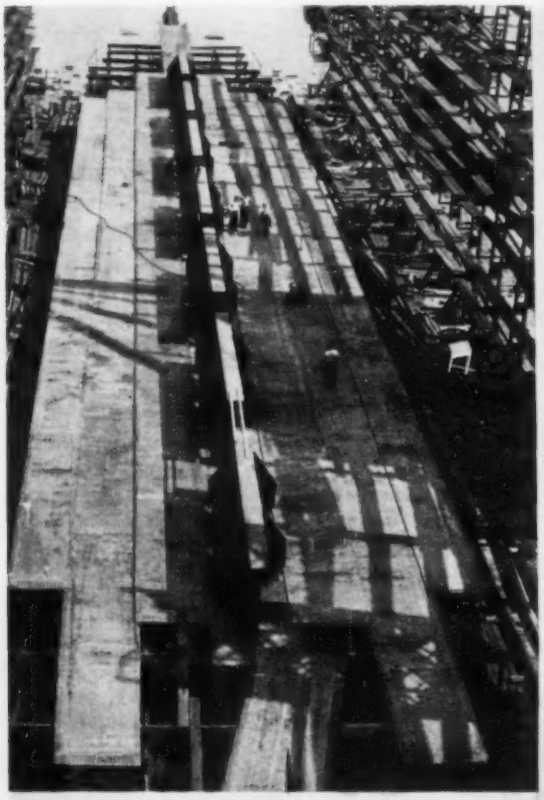
* Presented before the New York Section of AMERICAN WELDING SOCIETY on March 7, 1939.

† Chief of Hull Estimating and Designing Department, Federal Shipbuilding and Dry Dock Company.

Fig. 1—Start of Ship's Structure with Bottom Shell Plating and Shop Welded Assemblies of Center Vertical Keel. This Keel Is 7 feet 6 Inches Deep, 0.50-Inch Plating and Has Face Bar of 20 Inches x 1 Inch Plate. The Prewelded Assembly Includes Attachment Brackets for Bottom Transverses

Fig. 2—Erection of First Oil-Tight Transverse Bulkheads. These Bulkheads Are Completely Shop Welded and Are 35 Feet 4 Inches x 35 Feet 0 Inches and Weigh About 25 Tons Each

1



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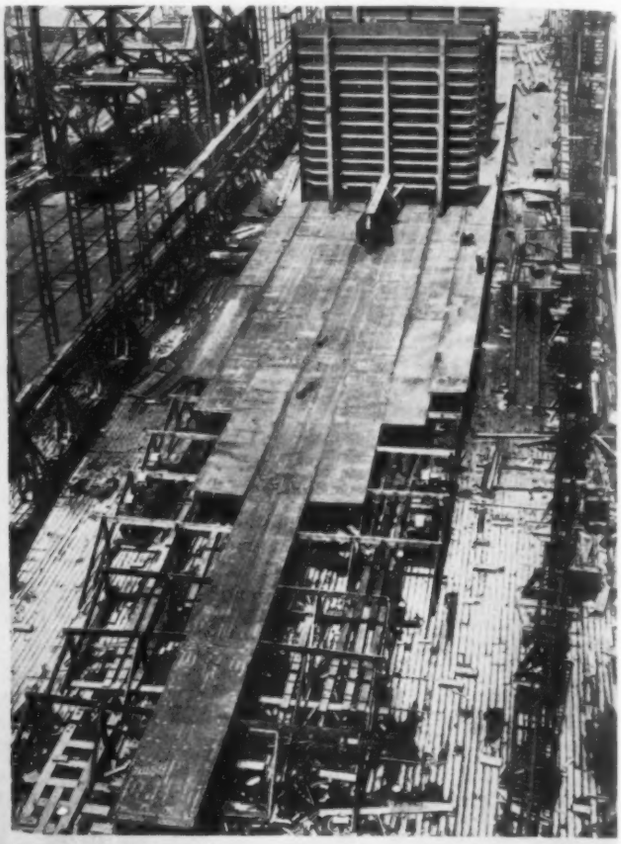

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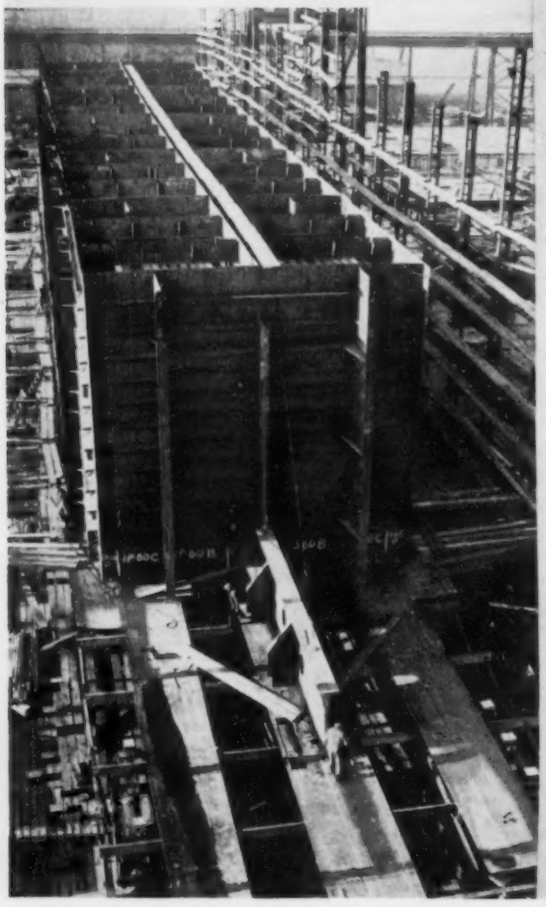

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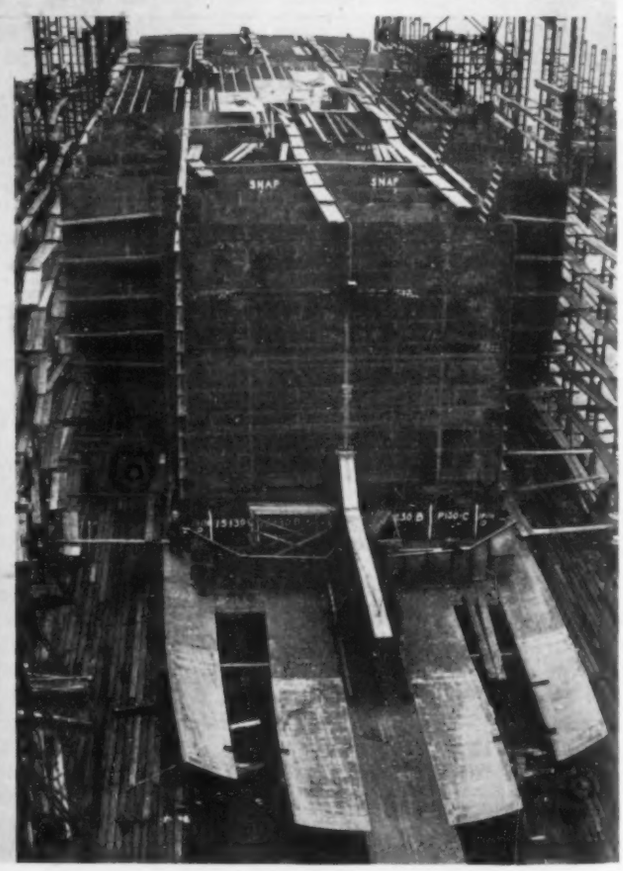


Fig. 3—Longitudinal Bulkheads, Deck Transverses and Deck Girder Have Been Added

Fig. 4—Transverse Bulkhead, Center and Wing Panels, Bottom Transverse and Center Vertical Keel Forward

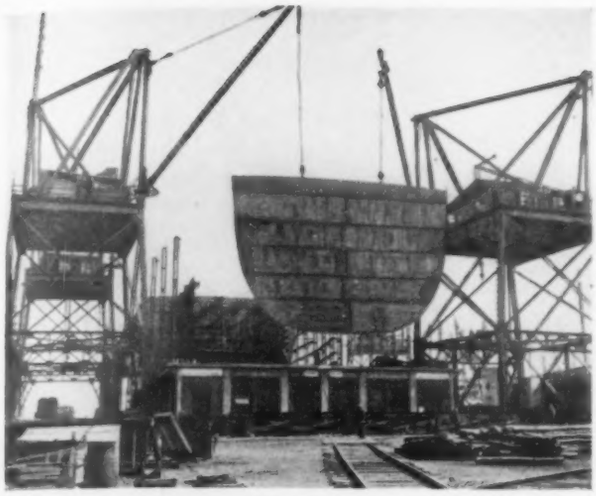


Fig. 5—Bulkhead at Aft End of Forward Hold. Bulkhead 40 Feet 6 Inches x 58 Feet 0 Inches, Weight 31 Tons

Returning to the question of design, the scantlings are worked out to satisfy the rules of the classification societies and, if of patented construction such as Isherwood longitudinal framing, with Isherwood's naval architect. The American Bureau of Shipping has been very helpful in the development of welded construction and is to be commended for its efforts along that line. In addition, detail plans when finished must meet with the approval of the owners' naval architects, and now also with that of the U. S. Bureau of Marine Inspection and Navigation.

Longitudinally framed construction lends itself best to welded tanker design as the major part of the welding is done lengthwise of the plates. The fewer the transverse welds, the less shrinkage and distortion. With welded construction it is possible to get better drainage and cargo tanks are easier to clean.

It appears more practical, at this time, to continue to use riveting at the ends of the ship where there are warped surfaces with so much "shape." With the normal form of ship it is difficult to assemble this part of the structure without considerable bolting, which requires holes, so that under these conditions riveting is advantageous.

Following the building of our first four large partially welded tankers, we received contracts for six slightly larger ones from the Standard Oil Company of New Jersey and the Pan American Petroleum & Transport Company. Their dimensions and particulars were as follows:

Length O.A.	450 feet–0 inch
Length B.P.	440 " –0 "
Beam, molded	66 " –6 "
Depth	34 " –6 "
Draft	28 " –$^5/_8$ "
Deadweight, about	13,080 tons
Gross tonnage	7,697
Net tonnage	4,653
Capacity in oil tanks	105,400 bbls.
Steam turbine propulsion	3,000 SHP
Steam pressure	400 lb./sq. in.
Speed	13 knots

The six ships were the S.S. "Esso Bayonne," S.S. "Esso Bayway," S.S. "Esso Houston," S.S. "Esso Boston," S.S. "Pan New York," and S.S. "Pan Maryland."

These tankers were built on a slightly different type of construction from our previous ones; using a bracketed longitudinal system instead of the bracketless, and thus eliminating the heavy shell doublers at the bulkheads. With this construction, heavy steel brackets were fitted through the transverse bulkheads connecting the shell longitudinals and the bulkhead stiffeners in adjacent tanks, thus making a very strong and rigid structure. Its superiority was proved by the decrease in deflection

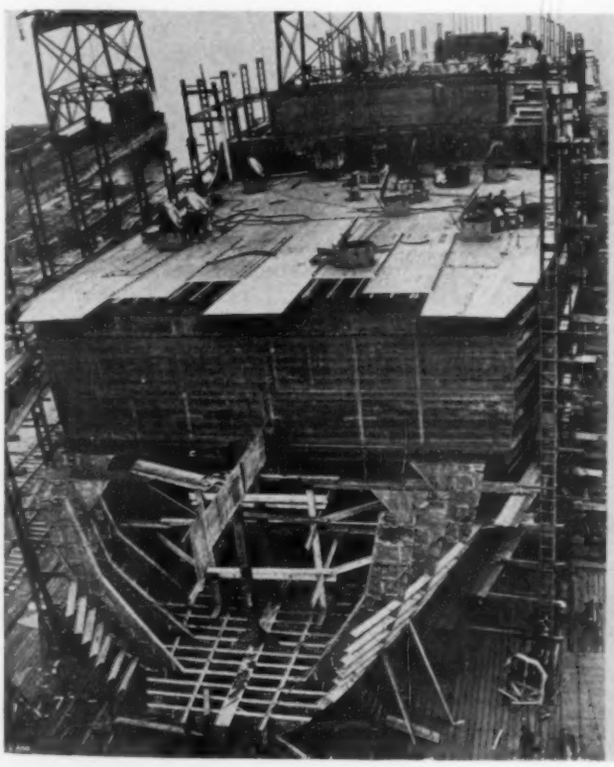


Fig. 6—Framing in Forward Hold Showing Transverses, Floors and Longitudinals Before Fitting Welded Deck

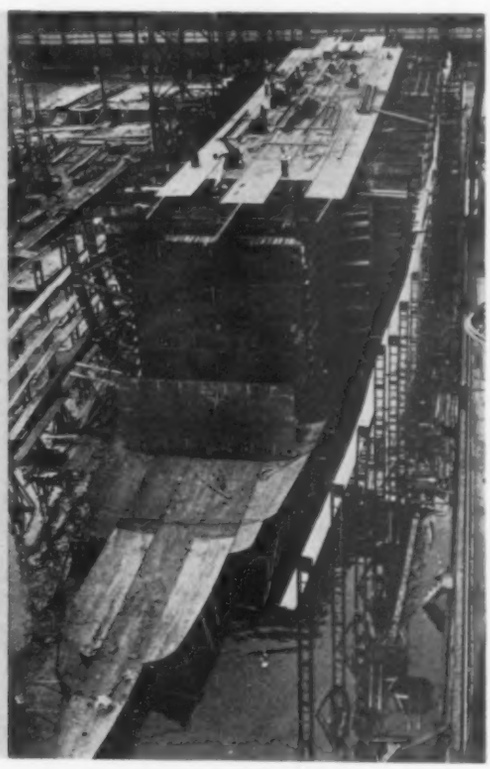


Fig. 7—After Shell Ready for Prewelded Assemblies of Inner Bottom. Also Side Transverses

of these ships in light and loaded condition. The cargo oil tanks were 34 feet long and two longitudinal oil-tight bulkheads were fitted throughout the cargo oil and bunker tank spaces.

In these tankers welding was used still more extensively than in our previous designs. In addition to the welded bulkheads and transverses in the cargo oil tank spaces, welding was used also on the bottom longitudinals to shell plating, part of the framing at the ends of the ship, vertical keel, inner bottom, intercostal girders and floors both forward and aft, and fore and after peak bulkheads. There were over forty miles of hand welding used on each ship. The inner bottom construction involved some interesting problems in assembly about which more will be said later.

The largest and most important prewelded assemblies were the cargo oil tank bulkheads. These were laid out to give a minimum of shop fabrication, and a large percentage of the steel was delivered directly to the welding assembly shop. Bulkhead plates were arranged on the welding slabs in the welding shop and tack welded together with the proper overlap for seams. Next the horizontal stiffeners were tack welded in place and then the vertical webs. All welding was done from the center of the bulkhead working out to the outer edge, and where a continuous weld was called for a "step back" method was used.

The plating on these bulkheads had an average thickness of $^1/_2$ inch and the horizontal stiffeners were 6-inch angle on toe at top of bulkhead to 14 inches flanged plate at bottom.

The vertical webs were about an average of 5 feet 0 inch deep and 0.46 inch thick plates with 12 inch face plate. Webs were stiffened with flat bar and bracket stiffeners. Three webs were fitted on the center section and one on the outboard panel.

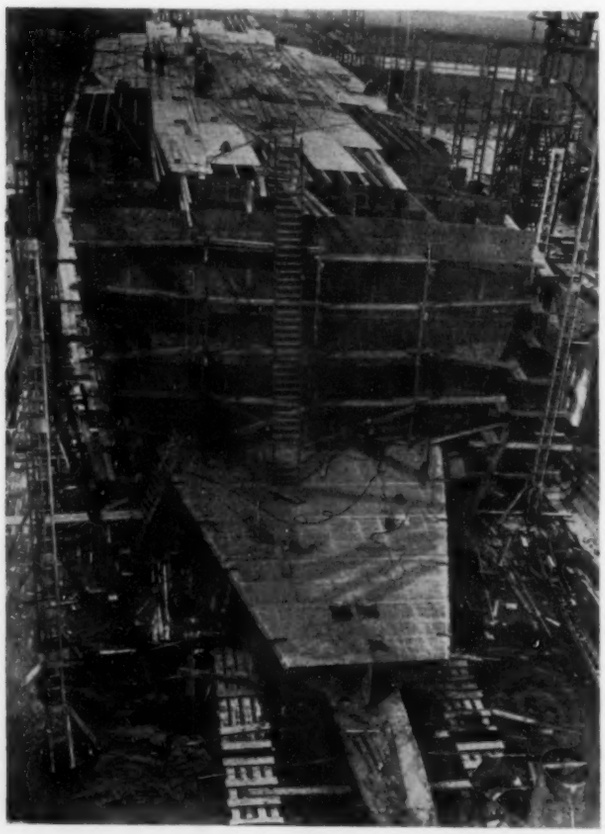


Fig. 8—Stern After Completing Installation of Inner Bottom, Including Floors, Intercostal Girders, Center Vertical Keel

Fig. 9—Ship on Ways Ready for Launching

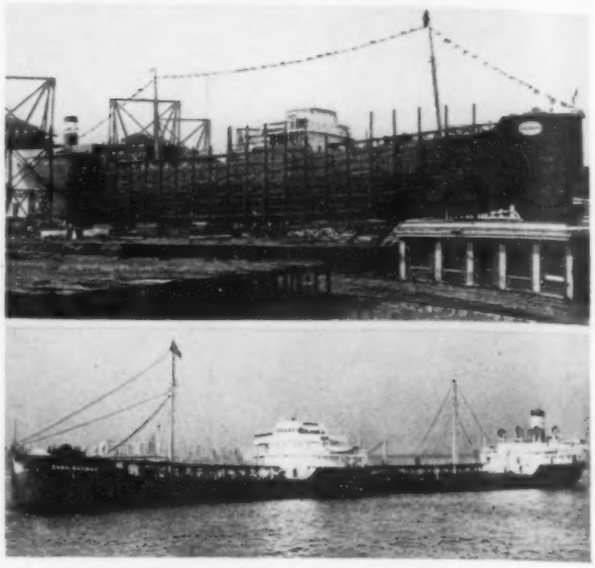


Fig. 10—Finished Ship on Trial Trip

This work was all arranged for down-hand and some vertical welding. After welding was completed on one side of the bulkhead, the parts were turned over by means of traveling cranes and the opposite side welded.

The seam laps on these bulkheads were mostly $2^1/_2$ inches and had continuous $^3/_8$-inch fillet weld on one side and $^1/_4$-inch continuous fillet weld on the opposite side. The stiffeners had intermittent fillet welds, both sides, spaced 10 inches to 12 inches, with continuous welds at junction with webs and from 5 inches to 9 inches at ends of stiffeners.

After completion of all shop welding on the bulkheads, they were trimmed exactly to shape to molds furnished by the mold loft. This procedure [assured] getting a ship absolutely true to shape and with less variation than a riveted ship. Similar methods were used in the preparation, assembly and welding of other parts in the shop, such as transverses, center vertical keel, deck girders.

The double bottom assembly is of special interest. This was built upside down with inner bottom plating running athwartships rather than the usual fore and aft arrangement. The assemblies were made up in sections about 20 feet long complete with floors, center keel and intercostal girders. All members were cut exactly to shape of bottom of ship. The seams in the top surface of the inner bottom were welded after the sections were assembled in the ship.

Among other items welded were the deck houses, miscellaneous bulkheads in quarters, second deck forward, fore and aft walkway, distilled and fresh water tanks, main and auxiliary machinery foundations, steering gear and winch foundations, oil-tight hatches, watertight doors and many small fittings scattered throughout the ship. Also certain pipe lines were welded, where the Bureau of Marine Inspection did not require stress relieving or X-ray testing after welding.

Federal Shipbuilding and Dry Dock Company is now building three much larger and faster tankers than those that have been described. They will be 525 feet long and will have a deadweight capacity of about 16,300 tons. The type of construction is similar to that of the ships just described. Also we have under way at Kearny two different designs of freighters for the U. S. Maritime Commission that will have considerable welding worked into the construction.

SHIP WELDING FROM THE Owner's Viewpoint*

By WM. B. JUPP†

WHEN one asks the question of an owner's interest in ship welding, it brings to mind costs and return on investment. This in turn breaks down into a number of points such as: Initial cost, time between contract and delivery of vessel, deadweight, reliability—safety, operating cost, maintenance, etc.

In considering each of these points a comparison is necessary between welded and riveted construction. This involves design and its effect on the various points I have just mentioned.

An opportunity to make some comparison has been afforded me in the past several years as Socony-Vacuum have built a number of vessels in which welding has been used to a great extent, which are similar to other vessels in the Socony fleet which are of riveted construction.

Before discussing these vessels in detail I should like to return to the question of the initial cost of a vessel to the owner. I must include in this item interest on investment prior to delivery and cost of inspection, which brings the time to construct the vessel in as part of the initial cost to the owner.

It is impossible to compare contracts for similar work at different times but where it has been possible to compare the cost of riveted to welded construction, the welded construction has shown either an earlier delivery date or a lower cost, or both, if any difference was shown in initial cost of construction. I do not recall any instance when the contrary was true. This cannot be evaluated in dollars except to say that in my experience it favors welded construction, particularly where more than one vessel of a given design is contemplated.

Deadweight is the most important item in comparing welded and riveted structures, as an increase in this offers lowering operating cost per ton or barrel for the life of the vessel. The saving in the steel required to build a welded vessel gives a considerable increase in deadweight over riveted construction.

Some years ago we built at the same time three sister motor barges, 262 x 43 x 15 feet, two riveted and the other with an entirely welded hull. The welded vessel was riveted only at the stern frame, stem and propeller struts. All three vessels were transverse framed. The welded vessel substituted flat bars and plates welded to the shell for the usual riveted construction.

Mr. Pluymert, Socony-Vacuum's naval architect, pointed out some time ago, in discussing these vessels, the saving in steel on the welded vessel as compared with her two sister ships. I repeat his statement that this tanker showed a saving in hull steel of 10.7%.

During the construction of this welded hull some bare rod welding wire was used. A recent examination of the hull showed no difference in corrosion in the welding with this wire and the welding with the covered wire. The vessel has had five years service and has developed no weld cracks.

Since building these three power barges, we have placed middle bodies in seven similar vessels, using the same transverse framing with welded construction. These new middle bodies in the old riveted ends showed a savings of about 7% in the total steel weight of the rebuilt vessel as compared with its original steel weight.

One of the middle bodies just referred to was built of Cor-Ten steel, which vessel has now been in service for nearly four years. A special covered wire was used in this welding. The scantlings required for mild steel were continued in this middle body. It is too early to predict what savings may be expected in corrosion with this material. It is interesting however to note in passing that the juncture between the Cor-Ten middle body and the mild steel ends has shown no excessive corrosive effect on either metal nor on the weld metal. There was a noticeable discoloration of the mild steel adjacent to the Cor-Ten steel after short service, indicating some slight reaction between the two metals. This has not been sufficient to cause any material reduction in plate thickness however.

A year ago the "Traverse City Socony" was built for Lake Service. The vessel is welded throughout the middle body with considerable welding at ends. The "New York Socony," which has an entirely riveted hull with transverse framing, is somewhat smaller than the "Traverse City Socony" but close enough in design to make a rather accurate comparison of hull steel weights. The riveted "New York Socony's" principal dimensions are 262 x 45½ x 15½ feet; the welded "Traverse City Socony" is 290 x 49½ x 20½ feet. The "New York Socony" was built with 730 tons of steel, whereas the "Traverse City Socony," some 30 feet longer and 4 feet wider and 5 feet greater depth, required only 140 tons more steel. Correcting the "New York Socony" steel to the size of the larger vessel would give a figure of 1075 tons of steel required for riveted construction, which is 204 tons, or 19% more steel than required in the welded structure of the "Traverse City Socony." This saving in steel was made possible by a carefully planned panel construction which afforded not only good possibilities of weight saving, but offered an opportunity to build a welded vessel with a minimum time from laying the keel to launching.

The vessel was contracted for late in the year for delivery before mid-season on the Lakes the following year. To accomplish this, it was decided to construct panels in the heated shop during the winter to avoid difficulty from cracks caused by welding in cold weather. The construction contemplated the following panels and assemblies:

Keel and keelsons
Bottom, port and starboard
Side panels, port and starboard
Deck, port and starboard
Rider plate and top strake of centerline bulkhead
Centerline bulkhead panel, and
Port and starboard transverse bulkhead panels.

* Presented at March 7th Meeting, New York Section, A.W.S.
† Marine Transportation Dept., Socony-Vacuum Oil Company.

Fig. 1—"Traverse City Socony" Placing Centerline Bulkhead Panel in Forward Tank. (Note Form in Bottom Panel)

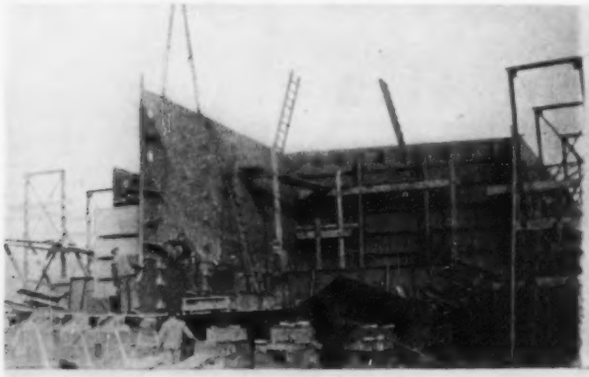
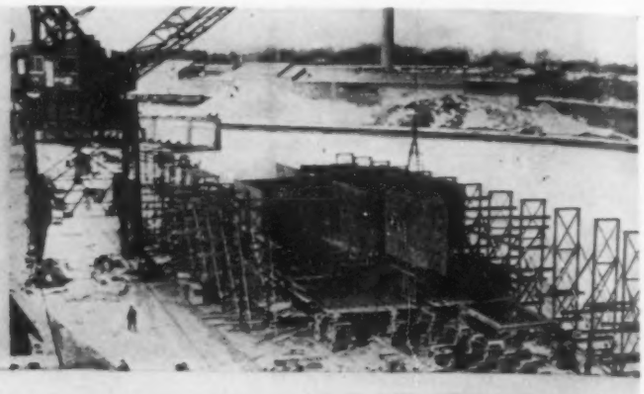


Fig. 3—"Traverse City Socony" Placing Centerline Bulkhead in Middle Body Section



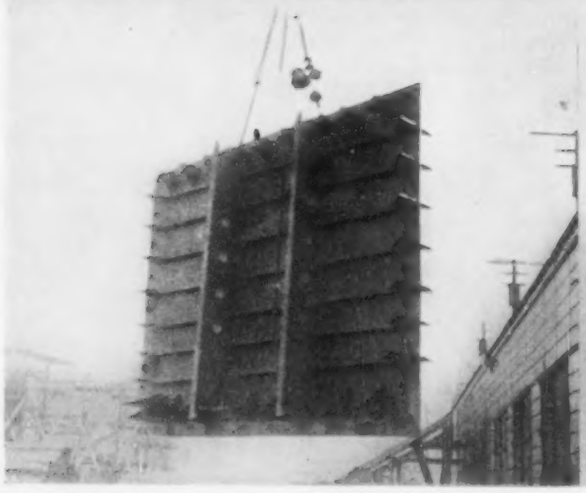


Fig. 2—"Traverse City Socony." Traverse Bulkhead Panel Leaving Ship for Yard

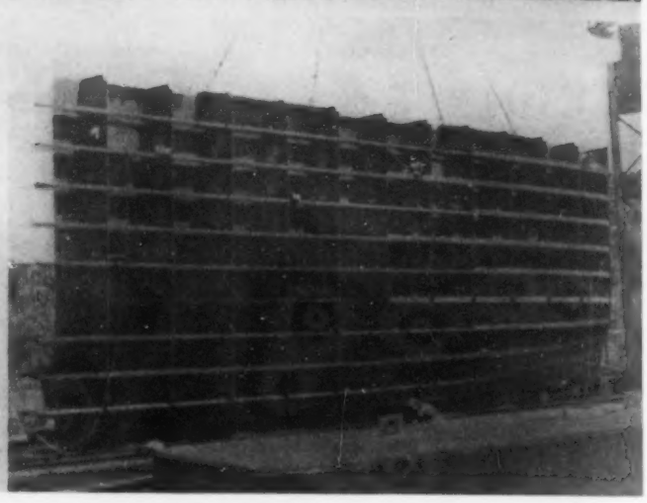


Fig. 4—"Red Crown." All Welded Double Bottom Section; Half Breadth and Two Tank Lengths. Dimensions 27 Ft. 5 In. x 68 Ft. 6 In.

These panels were built from December to March. Their construction was interesting in that the first panel of each type was carefully laid out from shrinkage data previously compiled. A jig was then made of the panel and all similar panels were made from this jig without layout work on the steel.

The first keel section was placed on Feb. 18th. The erection of the middle body, consisting of over sixty large panels and assemblies required less than sixty days and the completed hull was launched 104 days after laying the first plate.

These panels were all tank length and butt welded to the next similar panel at the next tank with the exception of the centerline bulkhead panel which was joggled to the panel in the next tank to allow adjustment to the butted shell and dark sections. In the ship's girth the bottom panels were lapped to the keel assembly and the deck panels were lapped to the rider plate. The bilge strake was placed after assembly of the panels as an outside strake forming a lap at these points. The stringer plate was fillet welded to the sheer strake against a plate bar landing previously welded to the sheer strake, thus eliminating the stringer angle.

This construction is particularly interesting in that it not only showed a very large saving in steel, but that it afforded a method for quick erection.

In the entire construction of this vessel, which required 80,000 feet of welding, only one crack occurred in the plating. This crack was located at the end of a stiffener in the center of a plate and was apparently due to placing the panel in the weather and exposing it to low temperature immediately after welding.

The fillet welding was a continuous single pass fillet weld made by A-C machine. All the sub-assemblies were carefully positioned prior to welding. The plates forming each panel were machine butt welded to form a single plate prior to assembling stiffeners and webs to the panel. Stiffeners and webs were mounted on the panel placed on a tilting table and the fillet weld again done by single pass A-C metal arc welding.

The Manitowoc Shipbuilding Company also built a large tanker the year prior to the "Traverse City Socony," which had a double bottom for the entire tank length. This was built in sections of two tank lengths and half breadth, 28 x 68 feet; each section weighed over fifty tons. These were built on the same tilting table to give down welding throughout the assembly.

Mr. Russell, who has just given us a very instructive talk on the welding of many tankers built by his company in the past few years, has given me some interesting data on some of the ships for which we were retained as consultants by the owner.

Hulls Nos. 141 and 142 of about 13,000 tons deadweight, to which Mr. Russell referred, were similar to the first two tankers built by the Federal Shipbuilding & Dry Dock Company after the depression. The design of these four vessels originally contemplate a considerable amount of riveting but as the design progressed, they modified the design to incorporate more and more welding. A review of the preliminary design of the tankers and the finished vessels showed that as the design progressed it was possible to eliminate over 300 tons of steel by increasing the amount of welding.

Only last week we launched a new 500-foot tanker

Fig. 5—"Mobilfuel." Center Tank Transverse Bulkhead Showing Flutes and Round Bar Brackets at Deck and Bottom Longitudinals

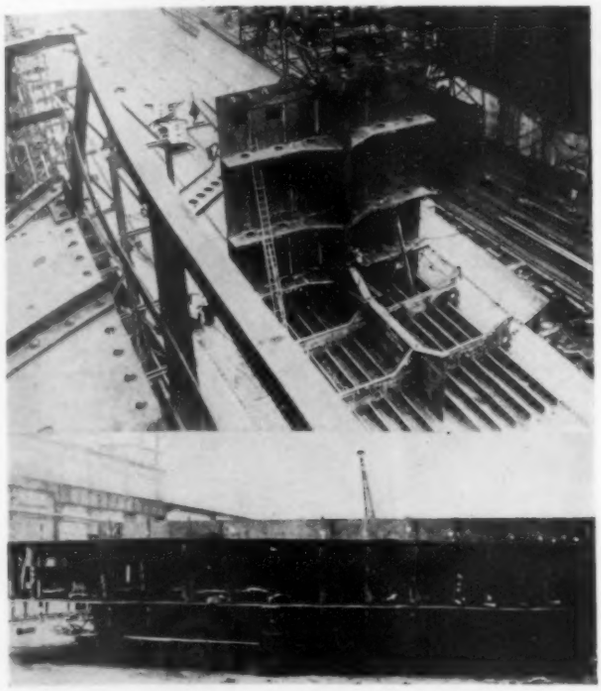


Fig. 6—"Mobilfuel." Wing Tank Cofferdam Section Showing Round Bar Brackets

which is all welded throughout the hull and deck houses, except for the strake laps of shell and main deck. The only other riveting in the entire hull was the deck longitudinals which were riveted to avoid overhead welding.

This design had been arrived at through progressive steps in the use of welding in large ships. The first welding which we used was to firmly secure the ends of riveted longitudinals in the bracketless longitudinal system. The shell butts on the bottom plating were welded before placing the butt straps or doublers, both for strength and to allow elimination of the inside strap, thus obtaining better drainage and less chance of an oil leakage between tanks through leaky rivets in the doubler.

In 1935 we first used the all-welded tank top and floor assembly in the engine room on the "Mobiloil" Class. This not only gave an excellent foundation for the propelling machinery but materially simplified the construction of the double bottom and saved considerable weight in this section of the vessel.

The welded tanker just launched includes all these features, but is built on the Bethlehem Frear fluted bulkhead system which reduces the surfaces in the tanks exposed for corrosion. The appearance of this hull at launching was quite interesting in that the shell and deck have no doublers or straps or butt laps in the entire length of the vessel. The amount of welding used is indicated by the fact that there are 375,000 feet of welding and only 125,000 rivets in the vessel, whereas a complete riveted vessel of this size will require 960,000 to 1,000,000 rivets.

It is too early to make a definite prediction on the hull steel saving in this hull over similar vessels in which much less welding or no welding was used. I can confidently make the statement however that the saving of steel in this design over a similar all-riveted vessel of practically the same dimensions will at least equal the figure of 15 to 16% predicted some years ago as the saving that could be made by welding on large ships. There is every indication that the saving in hull steel and machinery weight in this ship through the extensive use of welding with a design adapted to that method of construction will give this ship a deadweight in excess of 16,100 tons, which compares very favorably with the riveted "Magnolia" which was less than 15,000 tons after correcting for difference in beam.

The three comparisons of savings in steel weight, namely, the motor barge class showing a saving of just under 11%, and the intermediate size Lake tanker which shows a saving of close to 19%, and the 500-foot tankers just mentioned, give the possibilities offered by extensive use of welding in ship construction.

It is pleasing to be able to say that we have experienced no cracks either in the parent metal or weld metal of any welded vessel in service. In fact the welded canal barges have shown a much lower cost in repairs from contact with lock walls, etc., than the riveted motor barges in the same service.

The all-welded Lake tanker had a perfectly smooth underwater body. In the case of the 500-foot tanker, I also mentioned the complete absence of butt straps due to the welding. This elimination of laps and strakes on the hull shows a reduction in hull resistance of approximately 5 to 7%, which will reflect itself in an equivalent saving in the fuel consumption.

It is difficult to find figures on hull maintenance as distinguished from repairs, where welded construction can be compared directly with riveted construction over a sufficient period of time to give any indication in this direction.

Mr. Gilbert, President of the Oil Transfer Company has been good enough to give me some interesting data on two welded barges built ten years ago and similar riveted barges built at the same time.

The welded barges show a maintenance cost of less than half that of the riveted ones.

The experience with welding which I have outlined indicates that a welded vessel in comparison with a riveted structure shows possible savings:

(*a*) Initial cost is at least no higher for welded construction than for riveted.
(*b*) Equal or earlier delivery date.
(*c*) 11 to 19% reduction in hull steel and some reduction in machinery weight which together will show at least 6 to 7% increase in deadweight.
(*d*) Less frequent repairs for minor hull damage.
(*e*) 5% saving in fuel.
(*f*) 50% reduction in hull maintenance.

The owner must look to the extensive use of welding in ship construction if increased experience verifies the above indications drawn from limited available information.

In conclusion, it is the writer's observation that the shipyard with which he is associated is pretty well "sold" on welded construction. He believes the situation is similar in many other shipyards. As for the oil companies, the best endorsement is the fact that they continue to place orders for welded ships and like them.

THE IMPORTANCE OF WELDING in the Body Construction of Diesel-Electric Locomotives*

By JOHN H. HRUSKA†

SINCE the epoch-making trip of the first three-car Zephyr train from Denver, Colorado, to Chicago's Century of Progress Exposition in 1933, a rather complete change has occurred in the construction of high speed Diesel-electric locomotives. Subsequent to that time the formerly used riveting and bolting of car or locomotive bodies has been supplanted almost entirely with all-welded assemblies—at least when using ferrous metals for such construction. Accumulative experiences gained in the daily performance of the many Diesel-electric speedsters under very strenuous schedules were not only responsible for the practically complete replacement of the rivet joint by electric arc welding, but they did much more than that. They were the reasons for new inevitable developments, which have since been wonderfully fruitful in important adoptions of electric arc welding in numerous other fields of commercial endeavor.

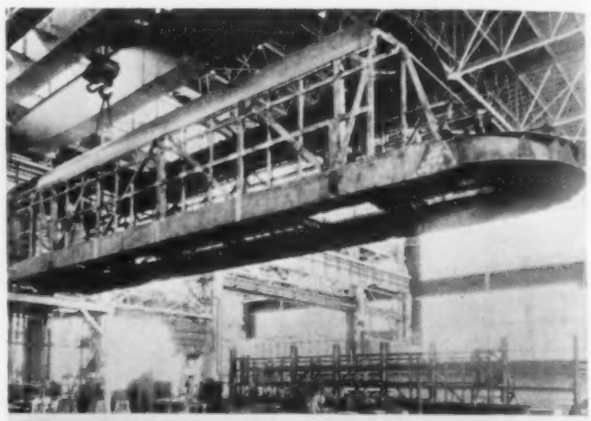
Let us stop for a few moments to scrutinize the technological advantages of welded *vs.* riveted construction with a specific view to high speed or heavily scheduled locomotives:

1. Uniform distribution of stresses throughout the car body.
2. Very marked reduction of the weight of the locomotive in reference to its power output.
3. Adoption of stronger materials for car body construction.
4. Decreased cost of production.
5. A stronger, more ductile bond between the welded members.
6. Neater appearance.
7. Much better resistance of joints to repeated stresses, at ordinary and subzero temperatures.
8. Easier cleaning and painting.

The welding technique applied in the construction of modern car bodies follows the highest standards dictated by the fundamental necessity of absolute safety. After being carefully dimensioned and checked theoretically for the various loads it is to carry under most trying conditions, the body is constructed in its various principal parts and then assembled.

The base or underframe of the car—probably the most complicated of the structure—consists of a series of specially designed beams welded to two long Z-bars (see Fig. 2). Three items of loading are decisive in the limits within which the designer must primarily determine mass effects and general dimensions, viz. the loading by the two engines and two generators as well as the location of the two bolsters which transfer the entire load to the trucks, axles and wheels, respectively. Rather simple fixtures for the exact location of the parts are being used in assembling the base structure. All the work is carried out on six welded supports permitting easy access to all parts above and below the fabricated base (see Fig. 1).

Fig. 1—A Triumph for Modern Arc Welding: An All-Welded Locomotive Frame Lifted by a 200-Ton All-Welded Crane in an All-Welded Factory Building



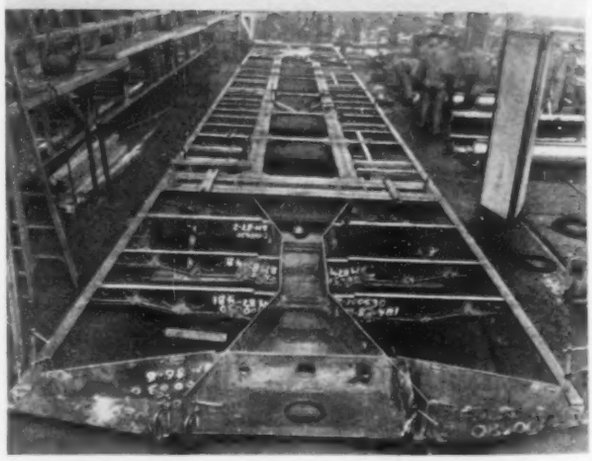


Fig. 2—Welded Underframe of Modern Streamliner

The side frames are similarly welded together on carefully proportioned welding fixtures, care being taken to allow for shrinkage to finished dimensions. Some conception of this important consideration will at once be apparent when reviewing the framework of the sides in Figs. 1 and 4.

Transverse deformative strains caused by the static loading of the under and side frames are mainly taken up by an especially constructed roof, which permits elastic longitudinal deformation between the bolsters, but which is practically rigid in planes perpendicular to

* The author of this paper received the second main award, $2,543.88, in Railroad classification of the $200,000 Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, in which savings of $1,600,000,000 were shown available to industry by wider application of arc welding. The paper, reproduced here in brief form, contains approximately 3800 words, 1 sketch and 15 photos.

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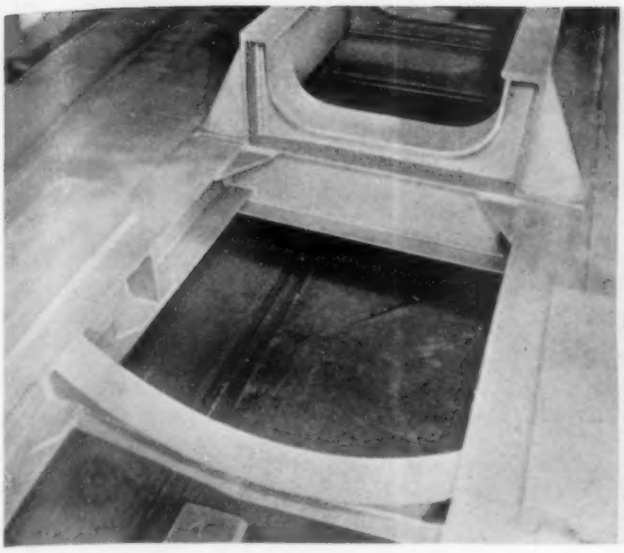


Fig. 3—Section of All-Welded Engine Bed

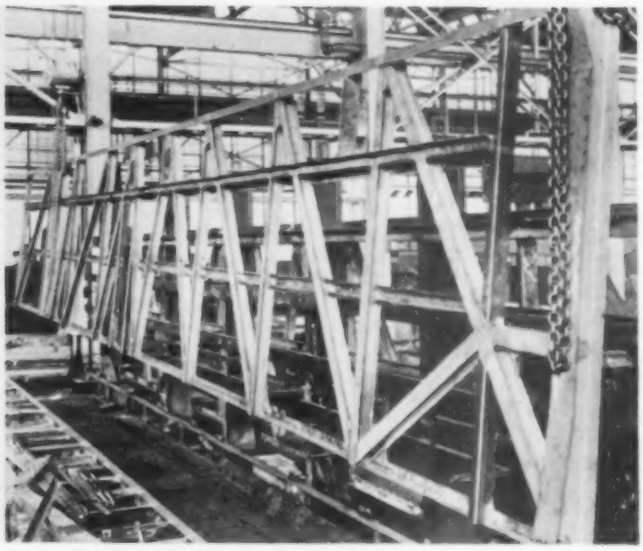


Fig. 4—Locomotive Sideframe Just After Welding Completed

it (see Fig. 5). In many cases, the roof is covered with columbium treated 18–8 stainless steel of 12 gage, other cars are topped with 12 to 14 gage steel of the nickel-copper type (see Figs. 1 and 6).

After completion of the two side frames and the roof, actual assembly of the car body commences. One side is first removed from the welding jig and welded in an upright position to the base frame. Careful positioning is maintained by tie rods tacked to the two frames. The other side is similarly connected to the base. While all the tie rods remain in proper locations the roof is finally welded in place. After adding the end sheets and additional crossrods, gussets, etc., the tie rods are removed and the minor parts, brackets, pipe clamps, fan frames and similar items may then be welded as per requirements. Before installing the engines, generators, blowers, pumps and auxiliary equipment the front is built up.

The "nose" of the modern Diesel-electric streamliner has appropriately been patterned according to experiences gained in automotive design. As in the roof construction, a framework is first fabricated upon which the properly shaped front sheets are welded. The entire body is then shot-blasted, inspected and repaired wherever some doubt exists as to first-class quality of any weld.

In the meantime, fuel tanks, water tanks, sand boxes and battery boxes have been manufactured by arc welding, tested for possible leakage by experienced inspectors. These may now be welded to the frame, thus fairly completing the fabrication of the car. The hatches are then being finished—also by welding—and are being applied after the power plant, wiring, piping are finished. These operations are finished by lifting the car with its contents over two trucks. Electrical connections and some piping is only necessary to actually enable the testing engineers to attempt the first trial run. Painting and trimming are then applied before final inspection, more testing and shipment.

DIESEL-ELECTRIC LOCOMOTIVES FOR SWITCHING

In building Diesel-electric locomotives either of the high speed passenger type or of the less spectacular, but equally efficient switching type practically all commercially known processes of modern arc welding are utilized.

The entire car body of Diesel-electric switchers is of arc-welded construction. This is especially true of the underframe, engineer's cab, tanks and many other parts of the car body. Bolts or other mechanical joints are used only for such parts requiring frequent removal, all permanent joints being made by butt or fillet welds. Wherever water-tight construction is desired, such as for cab or tanks, continuous welds are applied.

Without doubt, the largest all-welded part of the modern switcher is the underframe, the size of which may best be realized from the weight of this part of the car body. The unit for a standard 100 ton-600 hp. car weighs approximately 28 tons, whereas the 125 ton-900 hp. Diesel switcher has an underframe weighing about 44 tons.

In principle, the underframe for the 600-hp. car is a steel plate 40 ft. 3 in. long, 10 ft. wide and 2 in. thick, to which two center sills 40 ft. 3 in. long, 7 in. wide and 3 in. thick besides two side sills 36 ft. 9 in. long, 7 in. wide and 2 in. thick are welded. The 900-hp. frame is produced from two $4^1/_4$-in. plates, which are joined by two single bead automatic butt welds. In order to eliminate any possible cracking of the welds due to an internal notch effect, the beads overlap, thereby representing actually one solid piece of metal. The fillet welds of the sills are continuous on both sides. Welding stresses and deformation are eradicated by a carefully controlled heat treating process in a large gas-fired furnace. The straightness of the frames after heat treatment must be within $^3/_{16}$ in. over the top surface, which requirement facilitates the alignment of the engine, generator, fans, etc., during the subsequent assembly of the power plant. Both ends of the underframe are later equipped with all welded coupler pockets, which are welded to the frame in an inverted position. A $1^1/_2$-in. bolster web together with a bottom plate 40 ft. 3 in. long, 3 ft. 6 in. wide and $2^3/_4$ in. thick are then welded to the center sills. All steps and the $1^1/_2$ in. thick end plates are finally welded to the main structure of the underframe. All exposed welds are ground flush by means of portable grinding disks. A final inspection is made of all joints before the frame is turned over to the assembly department. There the base is placed on suitably designed welded supports, which arrangement permits a convenient access to above and below the top surface. This operation is followed by the installation of the welded engine bed, the welded cab,

fan housings, etc. A 26 ft. 9 in. long hood encloses finally the entire power plant of the locomotive.

TESTING THE SAFETY OF WELDED LOCOMOTIVE BODIES

As indicated in the introductory paragraphs of this paper, the car or locomotive body of the modern streamliner is fundamentally a framework or skeleton of beams joined by arc welding. Rather complicated mathematical relationships between loading, stresses and deflections have been developed by the designing engineers, which calculations have proved of inestimable value in the development of new and more efficient types of Diesel-electric high-speed locomotives. In the wake of these calculations, engineers and metallurgists have conceived a procedure of ascertaining actual conditions by imposing synthetic loads and measuring the resultant stresses and deflections in important members of the body. All such investigative work requires a metallic finish, i.e., shot-blasted surfaces of the entire structure, as well as skilled technicians and ample facilities for accurate measurements. In principle, the "safety" test consists of the following phases: according to a predetermined schedule loads are applied in various locations of the structure simulating those of actual operating conditions; these loads are produced by manually operated loading jacks, which were previously calibrated in a compression testing machine of the metallurgical laboratory. As many as sixteen of these jacks may be used in conjunction with one series of tests. The loading is conducted on actual or 100% pressures, followed by 125, 150 and 175% of actual working loads. After reaching these loads, careful examinations of all welds are made by inspectors and engineers. During all tests conducted so far, not a single defective weld has been discovered, thus proving the accuracy of calculations as well as reliability of workmanship.

RELATIVE ECONOMIES OF WELDED CONSTRUCTION IN DIESEL-ELECTRIC RAILWAY TRANSPORTATION

In order to delve into the problem of proportionate cost and ultimate operating economies brought about by the advent of the Diesel-electric locomotive, let us first compare the actual developments of the last year with those difficulties, which confronted the pioneers in the early attempts to adopt Diesel power for railway transportation. The original Diesel-powered switcher in the United States was built some fourteen years ago, but the 300-hp. unit was by far too heavy in proportion to the 60-ton nominal weight of the locomotive. It was not until about 1932, that a really light weight crankcase supplanted the very substantial casting, which—because of welding and many additional changes in the metallurgy of the Diesel engine—reduced the weight per bhp. to commercially feasible limits. A review of these factors, which made especially the high speed Diesel-electric locomotive a practical reality, would not be complete without some reference to the technical fact, that the readoption of riveted joints instead of welded ones would add at least 25 to 30% to the weight of the modern streamliner. Almost needless to assert, this difference would obviously affect the operating balance sheet very markedly.

Another first cost saving has been effected by the use of many welded structures instead of steel or iron castings. For example, the single item of a welded underframe *vs.* a cast-steel frame reduces the cost of a switching locomotive nearly 3%. If additional comparisons were made with many other welded against cast parts, this difference would certainly amount to well over 10% in initial cost saving alone—without even considering weight reduction in favor of the welded construction nor the undeniable improvement of reliability and safety of the welded portions of the locomotive.

In justice to the traditional steam locomotive, including the most advanced designs, with a multitude of castings, bolts and rivets, it is somewhat difficult to define what may be considered as proportionate cost saving of the welded car body. Pecuniary savings accruing to the railroads from the adoption of Diesel motive power may perhaps best be realized from the following tabulation of operating costs of various switching locomotives, wherein maintenance costs are significant, because they undoubtedly include items governed by the negligible attention given to car bodies.

Hourly Operating Costs of Various Switchers

Item	Steam Switcher	Oil-Electric Switcher 300 Hp.	Diesel-Electric Switcher 600 Hp.	Diesel-Electric Switcher 900 Hp.
Wages	1.70	1.70	1.70	1.70
Fuel	1.05	0.22	0.22	0.34
Water	0.08	..	..	..
Lubrication	0.02	0.25	0.08	0.13
Maintenance	1.35	0.21	0.22	0.16
Supplies	0.02	0.02	0.02	0.02
Insurance	0.01	0.02	0.02	0.02
Roundhouse exp.	0.30	0.05	0.05	0.05
Average cost	4.53	2.47	2.21	2.42

NOTE: The wages of "firemen" are included for all types, although their services are not essential for the oil and Diesel locomotives.

Fig. 5—Roof Construction on Welding Jig

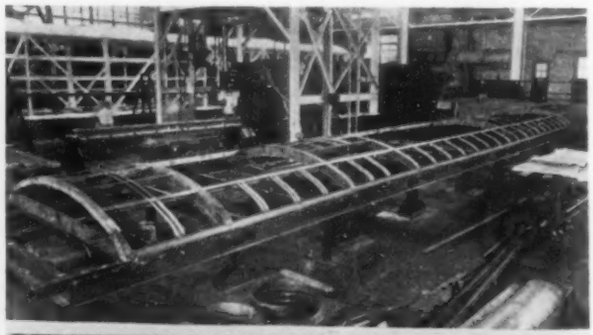


Fig. 6—The Finishing Bead of the Roof Construction

As indicated, the most impressive advantage of welding in the construction of Diesel-electric switchers is that of maintenance. Steam locomotives demand practically a 24-hour hostler service, whether they are in operation or not. Proper boiler efficiency and supervision of mechanical equipment of the steam locomotive require a regular repair force, which crew is frequently augmented when some work has to be rushed through or when the task is too heavy for the repair gang to carry out. In addition, the fire-boxes of conventional steam engines must be replaced every few years, which expenditure is naturally eliminated in Diesels. The welded underframe, cab, tanks, supports, etc., of Diesel switchers do not require any appreciable attention at all—except cleaning and painting. Even the customary periodical inspection of the car body structure has been dispensed with in most railroad yards due to the absolute reliability of the welded structure. This cannot be said in reference to riveted steam locomotive parts nor about the various castings used in their manufacture.

Even the most ardent conservatives in America's railroad directorates admit today, that the spectacular Diesel-electric streamliners as well as the nearly always available Diesel-electric switchers have made the public again railroad conscious. This change of attitude is admittedly a logical derivative of the consistent performance in regard to distance or time together with a proved reliability of the equipment. Both items are, in turn, functions of an advantageous combination of the Diesel engine and electric drive together with the application of welding and of new metals in the design of the rapidly accepted locomotive. It is finally interesting to note, that even the steam engine of yesterday has been given a welded streamlined covering so as to make it, at least, look modern! The welded Diesel-electric streamliner has thus proved to be a most effective impetus for safer, more economical and more interesting railway transportation.

Light Weight Arc Welding Gun

By DONALD MATHEWSON*

ARC welding of studs to secure wood decking on boats with light weight equipment has been accomplished by a young inventor who has been working on the theory for a number of years. His first gun was worked on a principal of an oil dash pot regulator but the finished gun which is now being placed in use is completely electrical. The oil dash pot being given up on account of change of oil viscosity and temperature.

This new type of electric arc stud welding gun weighs approximately six pounds and uses a 300 to 400 amp., d. c., welding generator for current supply. It makes a combination tool which allows the owner to use the welding generator for every day welding jobs when not being used for stud welding.

The regular welding leads are used on the gun which gives it great flexibility and ease of handling on the job. Eight to ten studs can be welded on in a minute with perfect and satisfactory results. Brass screws or studs can be welded to brass or steel plates in any position.

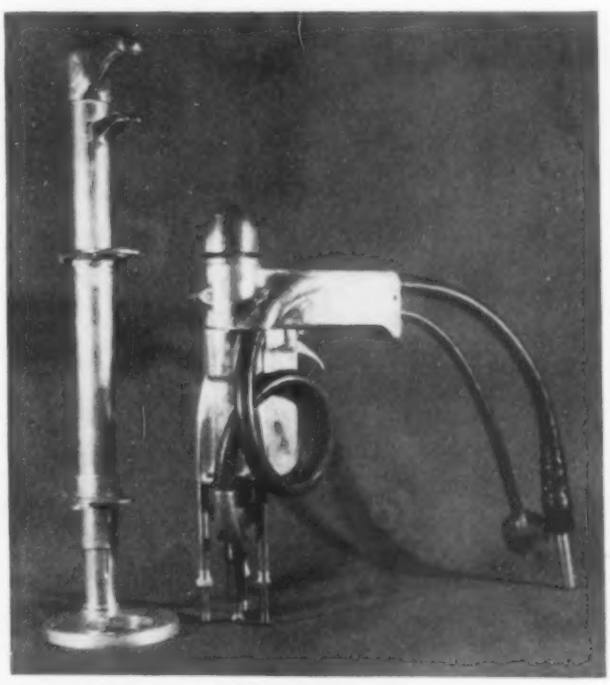
The gun is so designed that a tripod leg assembly replaces the regular stand when welding these screws to a plate where the welds do not have to be made through wood. The stand is a telescoping arrangement that allows the gun to be rapidly raised or lowered in the hole in the wood. The lever at the top of the stand controls the locking mechanism and holds it in any desired position.

To make a weld, a stud is inserted in the chuck and the lever on the stand is compressed which leaves the stand free. The gun can then be lowered down into the hole until the stud touches the plate. The stand is locked in this position by releasing the lever on the stand. The trigger is pulled which turns on the welding current and picks up the stud to a predetermined height. This creates the arc between the stud and plate making the molten crater for the weld.

At the same instant the timing device goes into action and at a given time the gun is tripped which forces the stud into the molten crater. As this occurs the current is turned off and the weld is complete. The gun is then pulled from the stud. It is foolproof and takes no exceptional skill to operate it.

The idea of securing wood decking on boats by end welded studs, instead of bolts, is not necessarily new. For a number of years the United States Navy has been working with this method but successful and satisfactory results were not obtained until this new type arc welding gun was developed.

Four of these guns are now being used by the navy department, three at Mare Island and one at Bremerton. This new method greatly simplifies a decking job which cuts the cost and at the same time gives a better job. In the event the decking should shrink or work loose, the stud deck still remains water tight. When redecking, all wiring, etc., need not be removed from the underside, as with the bolted method.



Light Weight Welding Gun

* 1616 Fern Place, Vallejo, Calif.

TESTING the PHYSICAL PROPERTIES of Welds*

By O. H. HENRY† and G. E. CLAUSSEN†

WE HEAR a great deal about the testing of welds, specifically, fusion and resistance welds. To most of us the subject of testing is distasteful. The welding operator must be irreproachably proficient at all times in order that his welds will meet the inspector's demands. The fabricator must take all possible precautions to be certain that his operators are supplied with first-grade equipment, filler rods and base metal. Steel and filler rod manufacturers are constantly improving their products to meet the increasing stringency of codes and specifications. It is no wonder that this prod to vigilance and exertion—testing—is usually an unpopular subject.

However, to two classes of people: the designer and the consumer, testing tells them most of what they wish to know about welding. The primary qualification of a good designer is his ability to increase over-all quality without increase in cost or, conversely, to reduce costs without sacrifice of quality. Economy in either circumstance dictates increasing speed to offset labor and overhead charges, and decreasing weight. The designer today distinguishes himself from his ancestors, who in Roman times were so conservative as to design on the basis of linear dimensions rather than on cross section, by utilizing the principles of high-speed fabrication and materials of dependable strength. The necessity for testing usually increases with the over-all speed of operations and is accentuated by the designer's dependence on strong steel and weld metal. The second beneficiary of testing, the consumer, requires no comment. It was largely at his demand that tests were evolved in the first place. The tests that have been devised are of four general types:

1. To prove the operator's ability to deposit a sound weld (operator's qualification).
2. To demonstrate the suitability of the combination of process, equipment and materials for producing welds of desired strength, ductility and soundness (qualification of welding process).
3. To verify that welds in welded products have the stipulated properties (production tests, often restricted to products and joints, such as boilers, in which hazard during service is a large factor).
4. To secure basic information of the nature of welded joints (experimental tests).

Compared with other types of joining processes, such as nailing, riveting, gluing, and so on, welding is quite easy to test. In fact, the simplicity of testing welds accounts for the great deal of weld testing that is being done. The soft pedal that has been used on the testing of other joining processes is related to the extreme difficulty encountered in subjecting other types of joints to anything like a searching test. The age of a process is no indication of the difficulty it may present to inspectors. Forge welding, for example, is far older than electric resistance welding, yet we are no nearer a complete solution to the testing problem for one type of weld than for the other.

In spite of the relative simplicity of weld testing, the subject is a bit complicated by the diversity of welding processes and types of welded joints that require testing. We will avoid confusion, therefore, if we separate the present elementary discussion according to types of test. Non-destructive tests are not mentioned, as they are the topic of another lecture in this series. Soundness tests are an indirect guide to physical properties and will be discussed briefly. Details of many of the tests described will be found in the Welding Handbook of the AMERICAN WELDING SOCIETY. The detailed descriptions of physical tests often seem unnecessarily long and trivial, yet it is characteristic of tests that they must be performed under rigidly controlled conditions. Slipshod testing is not only meaningless, it is misleading. It is a universal rule to discard from test welds all material containing craters or other end effects.

TENSION TESTS

In the tension test the two ends of the specimen are gripped in a universal testing machine. The machine then pulls the specimen apart. The results that can be obtained from a tension test are:

(*a*) Tensile strength = maximum load (lb.) during test divided by cross-sectional area (sq. in.) of specimen before it was tested.

(*b*) Yield strength = stress (load divided by cross-sectional area of specimen before test) at which the specimen exhibits a stated permanent elongation, often 0.002 inch/inch. The yield strength of weld metal and welds is seldom determined.

(*c*) Elongation (expressed in per cent) = increase in length of parallel section of specimen as a result of testing to fracture divided by the length of the parallel section before test. By parallel section gage length is meant the section of uniform cross section, which is usually 2 inches long. The gage length must always be stated in quoting elongation, thus: 20% in 2 inches.

(*d*) Reduction of area (expressed in per cent) = minimum cross-sectional area at fracture divided by the cross-sectional area before test.

Both elongation and reduction of area are measures of ductility, but reduction of area is seldom determined for weld metal and welds. The ductility of welded joints is usually determined by the bend test rather than the tension test, because often it is impossible to force tension specimens to break in the weld instead of the base metal.

All-Weld-Metal

The tensile strength of all-weld-metal is determined on a specimen 0.505 inch diameter (cross-sectional area = 0.200 sq. in.), 2-inch gage length, Fig. 1. Unthreaded ends may be used, if desired. To determine the tensile

* Presented as Lecture No. 6, Jan. 24th, New York Section Evening Lecture Course, Polytechnic Institute of Brooklyn.

† Polytechnic Institute of Brooklyn.

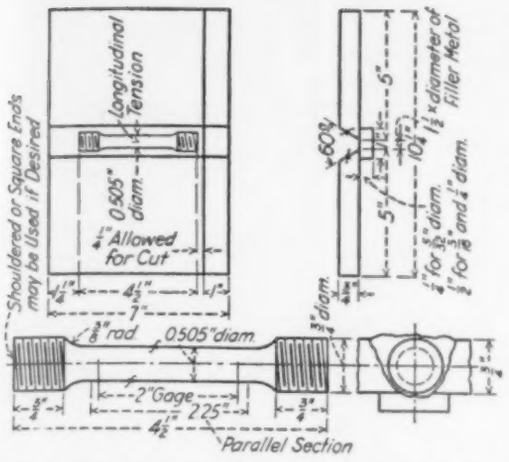


Fig. 1—Test Plate for Filler Metal 5/32 Inch Diameter and Larger and Method of Machining Specimens. A.S.T.M. A 205-37 T

strength of weld metal deposited by thin filler rods 1/8 inch diameter or less, which are used only for small welds, a subsize specimen 1/4 inch diameter, 1-inch gage length is used.

Butt Welds

The tensile strength of butt welds is determined on a weld that has been machined flush, Fig. 2. The specimen is reduced 1/4 inch on each side to form a reduced section specimen. Fracture is forced to occur in the weld, unless the plate is much weaker than weld metal. All sections of weld and heat-affected zone are subjected to maximum stress. The parallel section at the weld is prolonged 1/4 inch beyond the weld in order to avoid subjecting the weld to a stress concentration. For this reason results on a specimen with no parallel section are difficult to interpret and apply only to the central part of the weld. Sometimes a specimen with long parallel section is used (6 inches long, Navy Department). If, by chance, there is a zone near the weld that has been softened by the welding heat, it may reduce the strength of the specimen but, since structural zones in the joint are generally oblique to the load, fracture may not extend through the soft zone. In the rare instances in which it is desired to investigate the strength of zones of different structure special specimens must be cut from the joint. For welded pipe a specimen is used that is identical with Fig. 2, except that the curvature of the pipe is retained. For butt-welded sheet and tubing unmachined joints often are used. The location of fracture depends on the relative strength of the sheet and the shape of the weld.

BEND TESTS

The primary purpose of bend tests for welded joints is to determine ductility, more specifically to determine whether the weld cracks during bending. The cracks

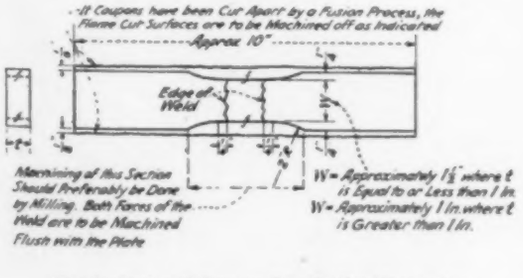

If Coupons have been Cut Apart by a Fusion Process, the Flame Cut Surfaces are to be Machined off as Indicated
Approx 10"
Edge of Weld
Machining of this Section Should Preferably be Done by Milling. Both Faces of the Weld are to be Machined Flush with the Plate
W = Approximately 1/4" where t is Equal to or Less than 1 in.
W = Approximately 1 in. where t is Greater than 1 in.

Fig. 2—Reduced Section Tensile Test Specimen

may originate at inclusions, improperly fused areas, or porosity, or may arise from an inherent lack of capacity for deformation. There are two types of bend tests: free and guided.

Free Bend Tests

The free bend test is used to determine the ductility of the weld metal only. A simple specimen is used, Fig. 3, with weld ground or machined flush, and edges rounded to prevent edge cracks. The same specimen is used for pipe, the curved surfaces of the pipe being removed by machining. As the specimen is bent, the distance between the scribed lines on the face of the weld increases. Bending is continued until cracks or defects 1/16 inch in any dimension are observed. The distance between the scribed lines is then measured with a flexible scale with an accuracy of 0.01 inch. The difference between the final and initial gage lengths, divided by the initial gage length and multiplied by 100 is the percentage of free-bend elongation, the gage length not usually being quoted. As suggested in Fig. 3, it is sometimes difficult to force maximum bending to occur in the weld rather

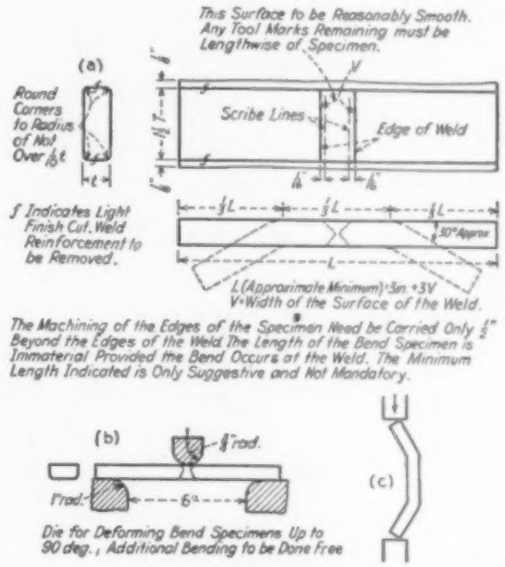

This Surface to be Reasonably Smooth. Any Tool Marks Remaining must be Lengthwise of Specimen.
(a)
Round Corners to Radius of Not Over 1/8 t
Scribe Lines
Edge of Weld
f Indicates Light Finish Cut. Weld Reinforcement to be Removed.
30° Approx
L (Approximate Minimum) = 3n + 3V
V = Width of the Surface of the Weld.
The Machining of the Edges of the Specimen Need be Carried Only 1" Beyond the Edges of the Weld. The Length of the Bend Specimen is Immaterial Provided the Bend Occurs at the Weld. The Minimum Length Indicated is Only Suggestive and Not Mandatory.
(b)
3/4" rad.
1" rad.
6 1/2"
(c)
Die for Deforming Bend Specimens Up to 90 deg.; Additional Bending to be Done Free

Fig. 3—Specimen for Free Bend Test and Method of Testing. A.S.T.M. A 205-37 T

than outside the weld. The plunger bend device for starting the bend correctly and grooved plates for preventing slippage of the specimen during free bending are recommended. To locate the maximum bend at the weld make a mark at the center of the weld and keep it tangent to a machinist's square during testing. Cracks often occur on the compression face of free bend specimens that have been bent flat without cracks on the tension face. The cracks in the compression side are sometimes associated with root defects but also may be due to the complex stress system created at the inner part of the bend in the later stages of the test.

Guided Bend Tests

The chief difficulty with free bend testing is the absence of uniformity in the shape the specimens assume at large bend angles. Some types of welded materials tend to peak more than others. As a result the same bend angle may be attained by two specimens, yet the elongation of the face of the weld may be greater in one weld than in the other. In the same way the same elongations may be obtained, but the bend angles may be different or the elongation may be more uniformly distributed in one specimen than in the other. The difficulty arises from

the absence of control of the shape of the bend. If the weld metal is considerably harder or softer than base metal the difficulty is marked.

To overcome the difficulty the guided bend test is used. The reinforcement of the specimens, Fig. 4, is removed, but they are otherwise untreated. The specimens are bent in the bending jig with a full stroke of the plunger. The specimen is considered to have failed if a crack exceeding $^1/_8$ inch in any dimension appears in either side of the specimen. Ordinarily cracks appear only in the tension side. The same type of specimen is used for butt welds in pipe, the curved surfaces being flattened in the jig during test.

Both face and root specimens are tested. The root bend specimen is the same as the face bend specimen except that the unmachined root is in tension during test to open any defects that may be present. In addition, side bend specimens are tested to expose faulty fusion along the scarves. Both root bend and side bend specimens bring to light important defects that may not be revealed in tension tests.

Although the guided bend test produces specimens of identical shape regardless of the relative hardness of the weld, it has been shown that peaking of the specimen away from the plunger may occur to different extents depending on the material. Consequently, uniform elongation is not insured. Furthermore, the results of guided bend tests are sensitive to changes in dimensions of specimen and jig and to changes in testing condition. It is a disadvantage, therefore, that a different bending jig is required for each different thickness to be tested, because the severity of the bending produced varies with the thickness of the specimen. Nevertheless, the advantages of the guided bend test in detecting flaws quantitatively outweigh the disadvantages. An adaptation of the guided bend test to oxygen cut surfaces has been made in which the oxygen cut surface is made either the side or tension face of a specimen that is bent around a semi-circular mandrel. The angle of bend in bend tests of welds is seldom used. For relatively brittle welds the angle of bend may be specified for the guided bend test, but is never specified for the free bend test.

SHEAR TESTS

Failure in shear tests usually occurs by sliding of one surface over another, in contrast with the separation of two parts that occurs in tension tests. Shear strength is the load required to break the specimen divided by the minimum cross-sectional area subjected to shear. Since it is extraordinarily difficult to eliminate bending and other stresses in shear tests, the usual shear test is a compromise in which shear stress is the predominant stress, but in which failure may occur otherwise than in shear under some circumstances. The shear strength is usually

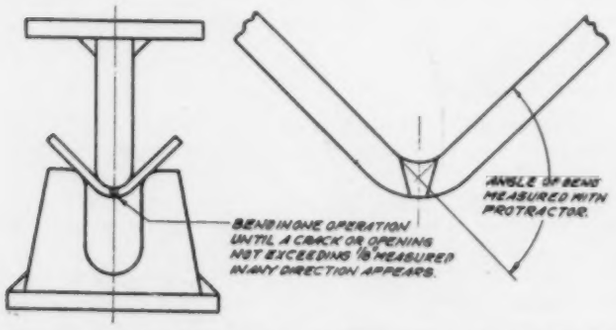

BEND IN ONE OPERATION UNTIL A CRACK OR OPENING NOT EXCEEDING ⅛" MEASURED IN ANY DIRECTION APPEARS.
ANGLE OF BEND MEASURED WITH PROTRACTOR.

Fig. 4—Guided Bend Test. Method of Determining Angle of Bend of Specimens of Low Ductility

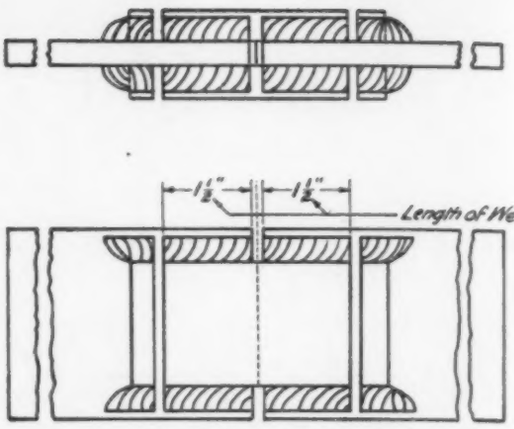


Fig. 5—Side Fillet and End Fillet Specimens

55 to 60% of the tensile strength of the material. It is not customary to measure ductility in shear tests.

Fillet Weld Shear Tests

Fillet welds are tested because they represent the majority of the welding in building construction, for example. Since the technique of fillet welding differs from butt welding, the specimens shown in Fig. 5 are used to determine the ability of the process and the operator to perform satisfactorily in different fillet welding positions. The welds are designed to fail before the base metal yields appreciably. The end fillet specimens are cut from a larger welded joint. On the other hand, each side fillet joint must be made separately. The ends of the side welds represent irregular material and are cut away before testing. The shear strength of fillet welds may be stated in two ways:

$$(1)\ \text{Lb. per Llinear inch} = \frac{\text{Maximum load (lb.)}}{\text{Length of the welds connecting a main bar to the two splice bars (inches)}}$$

$$(2)\ \text{Lb. per sq. in.} = \frac{\text{Maximum load (lb.)}}{\text{Average throat dimension (inch)} \times \text{length of the welds connecting a main bar to the two splice bars (inches)}}$$

The length of the welds connecting a main bar to its two splice bars is (Fig. 5)

(*a*) $4 \times 1^1/_2 = 6$ inches for side fillet specimens
(*b*) $2 \times 1^1/_2 = 3$ inches for end fillet specimens.

The dimensions of the welds in the specimen under test are substituted for $1^1/_2$ inches if they differ more than $^1/_{16}$ inch. The average throat dimension is 0.707 × leg. End fillets fail at higher stresses than side fillets, because there is a severe concentration of stress at the ends of side fillets. The end fillets are likely to give more irregular results than the side fillets.

Spot Welds

The shear test, Fig. 6, is the most acceptable test for spot welds at the present time, and is used widely in setting the welding machine. The single shear specimen, Fig. 6, involving only two sheets is most commonly used. Liberal edge distance should be provided. Unfortunately, once the specimen commences to deform the sheets tend to pry apart. As a result only one-half the weld spot is subjected to stress, which is no longer shear. Even testing machines having eccentric grips do not eliminate prying action.

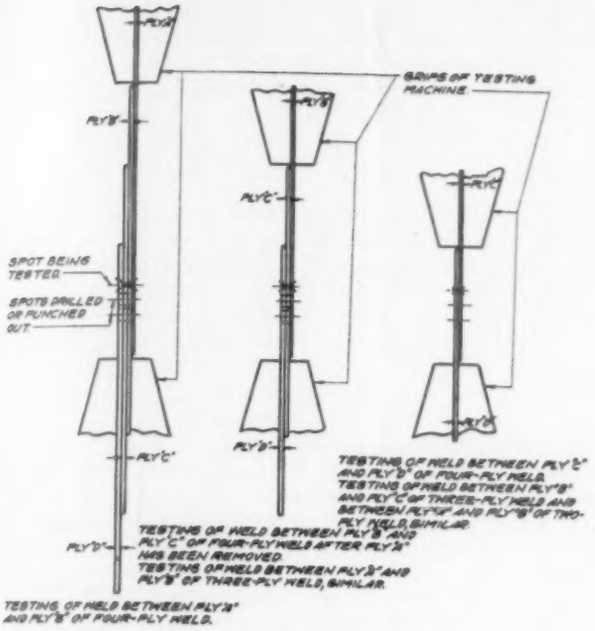

GRIPS OF TESTING MACHINE
SPOT BEING TESTED
SPOTS DRILLED OR PUNCHED OUT
TESTING OF WELD BETWEEN PLY "C" AND PLY "B" OF FOUR-PLY WELD. TESTING OF WELD BETWEEN PLY "B" AND PLY "C" OF THREE-PLY WELD AND BETWEEN PLY "B" AND PLY "B" OF TWO-PLY WELD, SIMILAR.
TESTING OF WELD BETWEEN PLY "B" AND PLY "C" OF FOUR-PLY WELD AFTER PLY "A" HAS BEEN REMOVED. TESTING OF WELD BETWEEN PLY "B" AND PLY "B" OF THREE-PLY WELD, SIMILAR.
TESTING OF WELD BETWEEN PLY "A" AND PLY "B" OF FOUR-PLY WELD.

Fig. 6—Method of Tension Testing Spot Welds. Ronay

A specimen with two spots in line and adequately spaced reduces torsional effects that may exist in the single-spot specimen, but does not prevent prying action. Two-spot specimens are more consistent than single spots but are likely to yield lower results because the load may not be equally divided among the two spots. Nevertheless, the single shear weld is the most widely used in practice and no better, simple test has been devised. The test usually is performed to determine the size of spot required to force failure to occur outside the weld. Under these conditions the maximum load is quoted as the result of the test. Should failure occur through the spot weld the shear strength is calculated by dividing maximum load by the area of the fractured spot. If the spot elongates during test to such an extent that a reliable measurement of its area cannot be made, the cross-sectional area of the spot-welding electrode may be substituted.

The single spot is not so often used in fabrication as series of spots fairly close together. The machine setting for the first spot does not deliver the same energy to successive spots as to the first spot, because existing spot welds act as shunts during the welding of subsequent spots between the same two sheets. To determine the strength of the third spot in a series, upon which the machine setting may be based, the specimens shown in Fig. 6 may be used, the two-ply specimen being most commonly used. The three-ply and four-ply specimens are so designed that the weld between each pair of sheets may be tested separately. Similar specimens may be used for seam welds, drilling being unnecessary, of course.

Spot welds in relatively thick material may be sheared by either tensile or compressive load. The three-ply tension specimen reduced prying to a negligible quantity, especially if the spacing strip butts the center plate. The three-ply tensile shear specimen may be used for sheet as well as for plate, but it represents a condition seldom realized in spot-welded fabrication. The compression test is not generally satisfactory on account of the buckling of the outer plates, which creates prying action. Buckling is decreased by reducing the height of the specimen.

Flash Welds

Well-made flash welds usually are stronger than base metal or that zone of the base metal that has been softened by welding heat. Therefore, failure in tension tests occurs outside the weld. To force failure in the weld the simplest expedient is the double shear test, which requires a machined specimen with two welds having the same spacing as the shackles. The shear strength is the maximum load divided by twice the cross-sectional area of the bar. The results of the test are sensitive to small variations in testing procedure, such as gap between the shackles and play between the specimen and the holes in the shackles, which, together with the frequent rebushing required by the shackles, accounts for the relatively small use that is made of the shear test for flash welds.

TORSION TESTS

Torsion tests are seldom applied to welds. Sometimes spot welds are tested by twisting, the angle of twist to cause failure being a measure of the ductility of the weld. The fundamental objections to the torsion or twist test are that it is inapplicable to thin sheet on account of buckling, and that the calculated stress corresponding to a given angle of twist varies directly as the diameter of the spot. Furthermore, it is difficult to secure uniform torsion because good spot welds often contain small blowholes that are not necessarily at the center of the weld.

NOTCH IMPACT TESTS

In the notch impact test, a specimen with a precisely machined notch of either Charpy or Izod type is gripped in a rigid vise and is struck by a pendulum moving at a speed of about 15 miles per hour, the root of the notch being in the region of the tensile beam stress. The energy adsorbed in fracturing the specimen is the measure of its resistance to shock in the sense that the material rapidly and safely equalizes the stress concentration created by the notch and the crack proceeding from it. There are three principal applications of the notch impact test to welds. First, the notch impact value at low temperatures is a sensitive indicator of the suitability of the weld for low-temperature service. Second, the presence of dangerous nitrides in the weld is readily detected by the notch impact test. The ability of all covered electrodes to exclude dangerous proportions of nitrogen from weld metal has deprived the notch impact test of most of its application at room temperature. In the third place, there is a body of opinion that regards high notch impact value as an assurance of high quality that is provided by no other test or combination of tests. For welded structures of extreme importance, therefore, a minimum notch impact value of the weld and heat-affected zone may be specified.

FATIGUE TESTS

Fatigue tests determine the maximum stress which a material can withstand if the stress is repeated many times, for example, one million times or more. Provided the specimen is not subjected to corrosion during test, there is a maximum range of stress, known as the endurance limit, which may be repeated an infinite number of times without causing failure. Experimental fatigue tests on large welded joints are being made in this country and routine tests of butt welds for railway

bridges are made in Germany. Unquestionably, fatigue tests will play a part in routine testing of welds in the future. At the present time no decision has been reached on the proper form of fatigue test to adopt for welds.

HARDNESS TESTS

Indentation hardness tests, in which the size of the indentation produced in the material by a hard indenter is the measure of hardness, are extremely useful for ascertaining that the hardness of hard facing deposits meets expectations. An average of three readings liberally spaced on a sound pad of weld metal so as to cause no bulging of the edge of the deposit usually is adequate for hard facing deposits. If the Brinell test is used on hard materials it is advantageous to coat the ball with Prussian blue to improve the sharpness of definition of the impression. In experimental investigations of the maximum hardness in a welded joint the Rockwell and especially the Vickers machines are most useful. The impressions are small and represent the hardness of a correspondingly small area of the weld or heat-affected zone.

CORROSION TESTS

In view of the slight difficulty with corrosion of welded joints, corrosion tests are not important. Besides, acceptable corrosion tests for welds have yet to be evolved. For welded 18–8 (18 Cr, 8 Ni, 0.07–0.12 C) a corrosion test consisting of immersion in boiling acid copper sulfate solution sometimes is applied to detect intergranular corrosion in the heat-affected zone. Tests for resistance to scaling at elevated temperatures are required by at least one consumer of heat-resisting steel filler metal. It is most difficult to simulate service conditions in corrosion tests. It is customary, therefore, to adopt a test that resembles service conditions (type of corroding medium, agitation, ratio of weld metal to base metal, presence of slag or flux, if any, on the weld) to some extent, usually small, and to require strict adherence to every stipulation of test procedure.

TESTS OF COMPLETED STRUCTURES

Proof testing of complete welded structures in addition to the customary non-destructive tests sometimes is specified by the consumer. For example, welded tanks usually must withstand, without evidence of failure, an internal pressure which is a stated percentage in excess of the highest expected operating pressure. Hammer testing of the weld or, in fact, any other testing procedure that may possibly sacrifice the strength of the vessel in future service should be applied only with great caution. It is uncommon to proof test other types of welded structures before they are placed in service. Proof testing of new welded designs, on the other hand, is commonly resorted to by the designer. The critical parts of the structure are coated with a lime wash before test. During test the dried lime flakes first from the most highly stressed regions. On the basis of the tests the designer alters his design to eliminate, as far as practicable, the regions of stress intensification.

SOUNDNESS TESTS

As indirect guides to the physical properties of a welded joint, soundness tests deserve some mention. The primary purpose of any soundness test is not the forecasting of physical properties but the demonstration of the ability of operator or process to deposit sound weld metal. While a satisfactory soundness test is no indication that the material possesses desirable mechanical properties, an unsatisfactory soundness test generally is accompanied by undesirable mechanical properties.

Nick-Break Test

In the nick-break test a fracture is produced by a single blow across the thickness of the weld on a span of 6 inches. The specimen is 2 inches wide and is nicked $^1/_8$ inch deep across the thickness of the weld by means of a saw. It is essential that the fracture be produced by a single blow in order that the fracture will exhibit any defects that may be present. According to A. S. T. M. Tentative Specification A 205-37 T, the fractured surface must show: (1) Complete penetration through the entire thickness of the weld, (2) absence of oxide or slag inclusions and (3) not more than six gas pockets per sq. in. of the total weld area exposed, no pocket exceeding $^1/_{16}$ inch in any dimension. Occasionally less stringent requirements are imposed on the nick break fracture. At one time it was suggested that the examination of bend fractures produced by slow application of pressure on unnicked specimens might usefully supplement the nick-break test. In this way it was possible to examine the fracture along the scarves. Unless the defects were unusually large, however, it was sometimes impossible to distinguish them in the fibrous fractures produced by slow bending.

Fillet Weld Break Test

A fillet weld of the type under consideration is deposited and a section is cut therefrom to eliminate the crater. The specimen is broken in a vise or by means of a hammer. The same requirements may be imposed as for the nick break test.

Etch Specimens

One surface of the break specimen is polished to a bright smooth surface and is etched in boiling 50% hydrochloric acid, for example. Etching is continued until all lack of soundness has been developed. Often expert examination is required for etch specimens.

Usability Tests

Specimens produced to demonstrate the suitability of a filler metal for its intended purpose, for instance vertical fillets, are usually examined for porosity, undercutting and overlapping, as well as for shape of bead. The same requirements as for etch specimens may be applied. Standard photographs of acceptable and unacceptable defects in fillet welds have been prepared by A. S. T. M. (A 205-37 T).

Density

The density of weld metal is determined by dividing the weight of a machined specimen $^1/_8$ to $^5/_8$ inch diameter, 2 inches long, cut from the middle portion of a butt weld, by the volume calculated from the dimensions. The density (specific gravity) should be at least 7.80 for the higher grades of weld metal (grades 2 to 10). Ordinarily, the density determination is used to check the indications of the break tests, upon which more significance and reliance are placed.

PHYSICAL PROPERTIES

The following paragraphs and tables list the physical properties often considered adequate for specimens of mild steel welded joints in the tests described in the

foregoing sections. It will be realized that the quoted values are representative, higher or lower values being mandatory or acceptable under some circumstances.

All-Weld-Metal Tensile Properties

The most detailed requirements are those of the A. S. T. M. Tentative Specifications for Iron and Steel Filler Metal, Table 1. The weld metals of higher grade number, above about 15, obviously are not intended for the most important applications. A common requirement of boiler codes is that the minimum tensile strength of all-weld-metal must be the same as the minimum tensile strength of the base metal on which it is to be deposited. An elongation of at least 20% in 2 inches is a common requirement.

Butt Weld Tensile Strength

Butt welds for important applications should have the same minimum tensile strength in the reduced section specimen as the minimum tensile strength of unwelded base metal, which is determined preferably in the stress-relieved condition.

Free Bend Ductility

Conforming to the high requirements of the first few A. S. T. M. grades, the 180° flat free bend test of joints of these grades must result in no defects. Lower grades, Table 2, have progressively lower requirements. Boiler codes specify 30% elongation across the weld.

Guided Bend Cracking

A guided bend specimen is unsatisfactory if cracks appear exceeding a stated length, usually $^1/_8$ inch, in any dimension.

Fillet Weld Shear Strength

The shear strength of fillet welds used with low-carbon, unalloyed steel of structural building or bridge grade (tensile strength = 60,000 to 72,000 lb./in.²) should not be less than 40,000 lb./in.² for side fillets nor less than 52,000 lb./in.² for end fillets; that is 60 to 80% of the tensile strength of base metal. With mild carbon steel plates for general plate construction (tensile strength = 55,000 to 65,000 lb./in.²) the shear strength should be not less than 36,000 lb./in.² for side fillets nor less than 48,000 lb./in.² for end fillets. The latter values are equivalent to 6400 and 8500 lb. per linear inch for $^1/_4$-inch fillets (leg = $^1/_4$ inch).

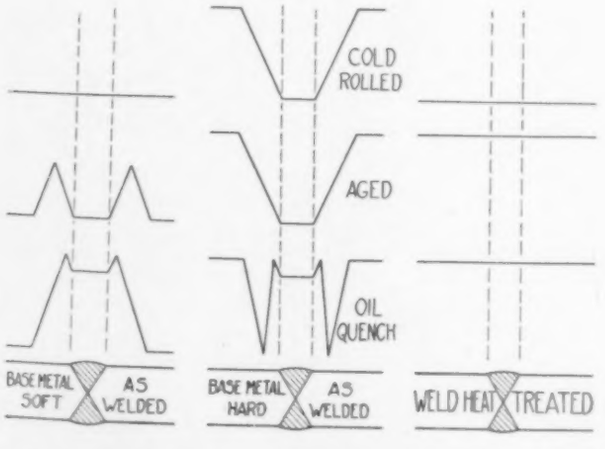


Fig. 7—Schematic Diagram Showing Effect of Welding on the Hardness of Cold Rolled (Middle Row), and Air Hardening (Lower Row) Alloys. Hardness Is Plotted Vertically

Spot Weld Shear Strength

Provided the weld and specimen are designed to force failure to occur as a shear failure across the weld, the shear strength of a single spot, which depends to some extent on its size, should be approximately 35,000 lb./in².

Notch Impact Value

A boiler code (Bureau of Engineering, U. S. Navy) regards 20 ft.-lb. Charpy or 50 ft.-lb. Izod at 20° C. as acceptable for welded joints in pressure vessels.

Fatigue Strength

Polished specimens of weld metal have the same rotating bend fatigue strength as rolled steel of equivalent quality. Unmachined welds and oxygen cut surfaces are accompanied by stress raisers which lower the fatigue strength to about that of an equivalent steel bar with a carefully drilled, central hole.

Alloy Steels and Non-Ferrous Metals

The values quoted in the preceding paragraphs show that, grain for grain, weld metal has the same properties as unwelded, hot-rolled base metal of equivalent quality. If models of welded joints, such as butt and fillet welds in the rough, are machined from rolled mild steel, they have essentially the same properties as welded joints of the same shape. Departing from the realm of mild steel, we find that the same statements apply to any material in the annealed state for which reliable welding processes have been developed and in the welding of which precautions are taken to avoid brittle, heat-affected zones. A soft zone near the weld is nearly always unavoidable in welding any material whose strength has been raised

Table 1—Tensile Requirements for Non-Stress Relieved Deposited Metal, According to A. W. S.-A. S. T. M. Tentative Specifications for Iron and Steel Filler Metal

Grade	Base Metal	All-Weld Tension Test: Tensile Strength, Min., Lb. per Sq. In.	All-Weld Tension Test: Elongation in 2 In., Min., Per Cent
No. 2	A. S. T. M. A 70 Firebox quality steel plate, tensile strength 55,000 lb. per sq. in., min.; or A. S. T. M. A 7 Steel for bridges, tensile strength 60,000 lb. per sq. in., min., with carbon not over 0.25 per cent and manganese not over 1.00 per cent; or equivalent steels	80,000	15
No. 4	Same as for Grade No. 2	75,000	15
No. 10	Same as for Grade No. 2	60,000	20
No. 15	Same as for Grade No. 2	60,000	17
No. 20	Same as for Grade No. 2	55,000	7
No. 30	Same as for Grade No. 2	47,000	5
No. 40	Same as for Grade No. 2	47,000	3

Table 2—Minimum Joint Requirements, Free Bend Test, According to A. W. S.-A. S. T. M. Tentative Specifications for Iron and Steel Filler Metal

Grade	Treatment of Welded Specimen	Outside Fiber Elongation, Per Cent
No. 2	Non-stress-relieved or Stress-relieved, as Specified	..
No. 4		..
No. 10		30
No. 15		25
No. 20		20
No. 30		10
No. 40		7

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The shear strength of fillet welds used with low-carbon, unalloyed steel of structural building or bridge grade (tensile strength = 60,000 to 72,000 lb./in.^{2}) should not be less than 40,000 lb./in.^{2} for side fillets nor less than 52,000 lb./in.^{2} for end fillets; that is 60 to 80% of the tensile strength of base metal. With mild carbon steel plates for general plate construction (tensile strength = 55,000 to 65,000 lb./in.^{2}) the shear strength should be not less than 36,000 lb./in.^{2} for side fillets nor less than 48,000 lb./in.^{2} for end fillets. The latter values are equivalent to 6400 and 8500 lb. per linear inch for $^1/_4$-inch fillets (leg = $^1/_4$ inch).

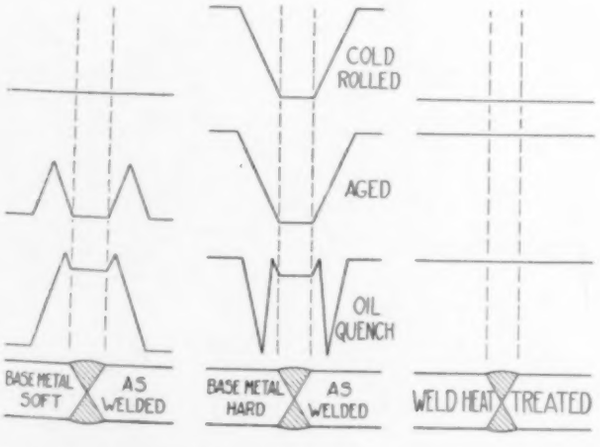


Fig. 7—Schematic Diagram Showing Effect of Welding on the Hardness of Cold Rolled (Middle Row), and Air Hardening (Lower Row) Alloys. Hardness Is Plotted Vertically

Spot Weld Shear Strength

Provided the weld and specimen are designed to force failure to occur as a shear failure across the weld, the shear strength of a single spot, which depends to some extent on its size, should be approximately 35,000 lb./in^2.

Notch Impact Value

A boiler code (Bureau of Engineering, U. S. Navy) regards 20 ft.-lb. Charpy or 50 ft.-lb. Izod at 20° C. as acceptable for welded joints in pressure vessels.

Fatigue Strength

Polished specimens of weld metal have the same rotating bend fatigue strength as rolled steel of equivalent quality. Unmachined welds and oxygen cut surfaces are accompanied by stress raisers which lower the fatigue strength to about that of an equivalent steel bar with a carefully drilled, central hole.

Alloy Steels and Non-Ferrous Metals

The values quoted in the preceding paragraphs show that, grain for grain, weld metal has the same properties as unwelded, hot-rolled base metal of equivalent quality. If models of welded joints, such as butt and fillet welds in the rough, are machined from rolled mild steel, they have essentially the same properties as welded joints of the same shape. Departing from the realm of mild steel, we find that the same statements apply to any material in the annealed state for which reliable welding processes have been developed and in the welding of which precautions are taken to avoid brittle, heat-affected zones. A soft zone near the weld is nearly always unavoidable in welding any material whose strength has been raised

Table 1—Tensile Requirements for Non-Stress Relieved Deposited Metal, According to A. W. S.-A. S. T. M. Tentative Specifications for Iron and Steel Filler Metal

Grade	Base Metal	All-Weld Tension Test: Tensile Strength, Min., Lb. per Sq. In.	All-Weld Tension Test: Elongation in 2 In., Min., Per Cent
No. 2	A. S. T. M. A 70 Firebox quality steel plate, tensile strength 55,000 lb. per sq. in., min.; or A. S. T. M. A 7 Steel for bridges, tensile strength 60,000 lb. per sq. in., min., with carbon not over 0.25 per cent and manganese not over 1.00 per cent; or equivalent steels	80,000	15
No. 4	Same as for Grade No. 2	75,000	15
No. 10	Same as for Grade No. 2	60,000	20
No. 15	Same as for Grade No. 2	60,000	17
No. 20	Same as for Grade No. 2	55,000	7
No. 30	Same as for Grade No. 2	47,000	5
No. 40	Same as for Grade No. 2	47,000	3

Table 2—Minimum Joint Requirements, Free Bend Test, According to A. W. S.-A. S. T. M. Tentative Specifications for Iron and Steel Filler Metal

Grade	Treatment of Welded Specimen	Outside Fiber Elongation, Per Cent
No. 2	Non-stress-relieved or Stress-relieved, as Specified	..
No. 4		..
No. 10		30
No. 15		25
No. 20		20
No. 30		10
No. 40		7

by cold rolling or by heat treatment. For example, there is a soft zone adjacent to welds in cold-rolled sheet of any metal and in precipitation hardened alloys such a duralumin, as well as in oil-quenched and toughened aircraft sheet and tubing. Hence, an approximate guide to the physical properties of welds in any metal may be obtained by ascertaining the strength of the hot-rolled or annealed material and applying the ratio suggested in the foregoing section for the relative strength of a butt or fillet weld in any of the tests described.

DISCUSSION

The physical properties of a welded joint depend on three factors:

1. Base metal (heat-affected zone)
2. Filler metal
3. Shape

1. *Base Metal (heat-affected zone)*

The following occurrences that may accompany welding affect the physical properties.

(*a*) Hardening—in steels with over about 0.25 C, for instance, the heat-affected zone is hardened, sometimes to a dangerous degree, depending on the welding process and unless preheating or annealing are employed. Corresponding to the increased hardness of the zone, there is increased strength (no change in elastic moduli) and decreased ductility. The zone of decreased ductility is sensitive to cracking under shock loads.

(*b*) Softening—there is always some zone adjacent to a weld that has been raised above the critical range or recrystallization temperature. If the material has been cold rolled before welding, Fig. 7, it will be softened regardless of the rate of cooling; if the material has been quenched and tempered or precipitation hardened before welding, the rate of cooling after welding will determine the extent of the loss of strength. In general, precipitation hardened alloys will revert to the soft condition. Alloys depending on a "martensite" type of transition, such as steels, will be rehardened if the rate of cooling after welding is sufficiently rapid (small welds, such as spot welds). There always will be some zone near welds in quench hardened steels and similar alloys that has been heated into the drawing range but not into the critical range. The zone in question will be softened. Depending on its size with respect to the weld, the softtened zone may or may not be the location of fracture. However, the softened zone will lower the permissible design stress of the joint. Under some circumstances the range of softening temperatures may be attained for so short an interval that softening will be inappreciable.

(*c*) Intergranular effects—in rare instances the welding operation may cause precipitation of a constituent in undesirable form in the heat-affected zone. For example, in unstabilized, high-carbon 18–8 sub-microscopic carbides deposit in the grain and twin boundaries as a continuous network susceptible to corrosion by extremely corrosive reagents. Another example of intergranular effects is the intergranular penetration of bronze-welding metal into stainless steels under some peculiar conditions.

(*d*) Grain growth—in metals that do not undergo an allotopic change, for instance, copper and nickel, the high temperature during welding enlarges the grain size. Sometimes grain growth is accompanied by embrittlement, as in 18% Cr iron. In other steels the grain growth attendance upon welding may induce susceptibility to hydrogen embrittlement at elevated temperatures. Even if the metal undergoes an allotropic change (steel) the grain size adjacent to the weld is coarse, but is refined by the reheating effect of a subsequent bead of weld metal.

2. *Filler Metal*

(*a*) Composition—physical properties are largely determined by composition. Sometimes there is a "hidden" element in the composition that is revealed only when special tests are applied. For example, columbium or titanium (0.5–1.0%) added to 18–8 stainless steel has no appreciable effect on strength or ductility but prevents intergranular corrosion at cross welds. The addition of ½% molybdenum to plain carbon steel is another instance. The addition has scarcely any affect on properties at room temperature, but raises the creep strength at elevated temperatures to an important extent.

(*b*) Porosity and inclusions—the obviously undesirable effect of excessive porosity and slag on the physical properties of welds is too well known to require comment.

3. *Shape*

Aside from the size of the weld, which is the determining factor for the strength of fillet welds, the shape is important principally for impact resistance and fatigue strength. Undercut and incomplete root penetration are tiny defects from the viewpoint of cross-sectional area, but they play havoc with impact and fatigue value. These small defects are also focal points for corrosion. The large-scale contour of welds is equally important for fatigue strength, welds with pronounced reinforcement or convexity being undesirable from the standpoint of physical properties.

It is true that we may dissect the factors that constitute a welded joint and find numerous small difficulties. Nevertheless, there is a positive viewpoint as well as a negative. For most, if not all of the difficulties created by the heat-affected zone there are well-known remedies. Filler metal and shape of weld are faultless in the hands of an expert operator using materials qualified by test. Consequently, it remains for us to become better acquainted with the properties of the welds that can be produced in engineering materials.

Annual Meeting Program

The Annual Meeting of the AMERICAN WELDING SOCIETY will be held in Chicago during the week of October 22nd in conjunction with the National Metals Exposition. The National Program Committee has arranged sessions on the following subjects: Welding in Construction Work, Industrial Research, Production Welding in Light Gauge Material, Fundamental Research, Machinery Construction, Welding in General Construction, Flame Hardening and Hard Surfacing, Resistance Welding, Welded Piping, Pressure Vessels and Boilers, Cutting and Welding in Steel Mills, Welding in Structural and Ship Work, Railroad Session and a Miscellaneous Session.

Altogether some sixty papers will be presented.

Indications are that more than a thousand welding engineers will attend the various technical sessions of the Society. No one can afford to miss this opportunity.

WELDING A POT CHUCK

33 Feet 7 Inches in Diameter Weighing 96,200 Pounds

By E. J. CHARLTON*

FOR use in slotting the teeth of forged internal gears which rotate the turrets supporting three 16-inch guns on battleships, Camden Forge Company, Camden, N. J., recently purchased a welded steel pot chuck, 33 feet 7 inches in outside diameter, 3 feet 6 inches high, weighing 96,200 lb. It is believed to be the largest pot chuck ever built and was designed and fabricated by our company, in collaboration with the engineers of Camden Forge Company.

Design, fabrication, transportation and installation of the pot chuck involved some unusual and difficult problems.

DESIGN AND FABRICATION

Because of the accuracy required in slotting the turret ring gear teeth, the rigidity of the pot chuck was of primary importance. The preliminary design for the chuck was based on production in cast iron. Due to limitations on the sizes of castings obtainable, the design was evolved around a number of segmental castings. Likewise because of casting limitations, the radial spokes which are of extreme importance in the over-all structure were T-shaped in cross section, and designed for the use of metal about 2 inches in thickness. It was estimated that, with the preliminary cast-iron design, the pot chuck would weigh approximately 105,000 lb.

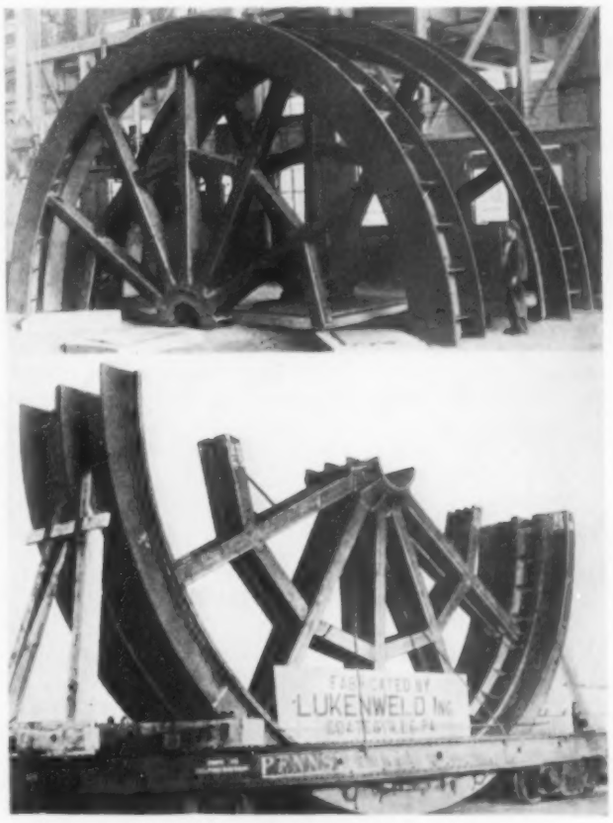
In redesigning for welding, it was recognized it would be preferable to build the pot chuck in one piece at the weldery since alignment might have been better controlled. However, one-piece construction could not be employed because of the impossibility of shipping such a large structure. It was decided, as the most practical and efficient expedient, to use a design comprised of two half sections, and two loose central spokes, welded separately and shipped to Camden for the welding of the two half sections and the two loose spokes into the completed pot chuck.

In order to provide added torsional rigidity, the T-shape construction of the radial spokes was abandoned, and box sections were employed. Each of the twelve spokes consists of two channel members, formed on a press brake from steel plate $^5/_8$ inch thick by By-Products Steel Corporation, another division of Lukens, also of Coatesville, Pa. The two channel members of each spoke were butted together on their edges and welded on both sides along their full length of 13 feet 2 inches to form a box 10 inches wide, which tapers from a height of 17 inches at the hub down to $8^1/_2$ inches at the circumference of the ring in order to provide clearance. For accessibility for internal welding, elliptical openings were flame-cut in the sides of the spokes. At the circumferential end of each spoke, and from the main web of the pot chuck, sections were removed by flame-cutting in order to bring each spoke through the main web and permit the use of a full-strength joint in welding the spokes to the main web. If the radial spokes were welded to the inside of the main web, it would have been necessary to make all of the welds internally in confined space at those points through small access holes cut in the spokes. Obviously, such welds would lack the efficiency of the full-strength joints deemed necessary and obtained with the design used.

Twelve segmental spacers fitting between the spokes were also formed in one piece from steel plate $^1/_2$ inch thick, on a press brake. Each spacer is a three-quarter box section, with one side open but with the edges flanged down to a depth of 2 inches. The spacers were 10 inches wide, 10 inches high and approximately 4 feet 4 inches

Two Welded Pieces Too Big to Ship as One

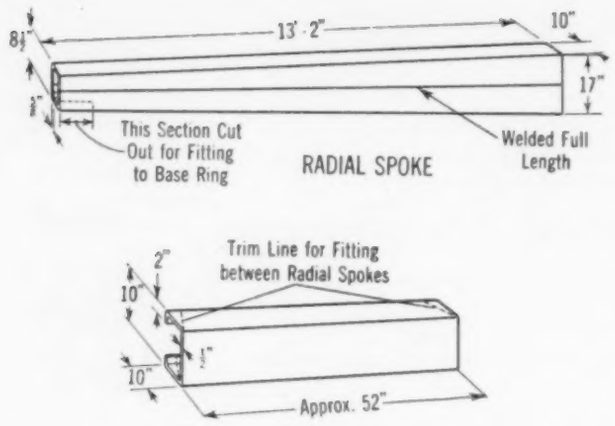
These two half circles form a welded steel pot chuck, 33 feet 7 inches in diameter and weighing 96,200 lb.



Only One Inch Clearance Overhead!

Only three inches between the bottom of these two rings and the rails! Only one inch between the top of the rings and overhead structures at some points along the right of way!

* Designing Engineer, Lukenweld, Inc., division of Lukens Steel Co., Coatesville, Pa.



Design of Box Section Spoke and Spacer Used in the Construction of Welded Steel Pot Chuck

in length, with their ends trimmed by flame-cutting at the angles required to fit between the radial spokes.

Forming a transition member, the central hub section rigidly ties the ends of the radial spokes into the center or innermost ring, which was formed in halves. The two pieces of the inner ring were welded together in the final assembly. The entire central hub section is 5 feet 0 inch in diameter, while its inner ring is 30 inches, in inside diameter, 30 inches wide, and made by flame-cutting and bending a steel plate $2^1/_2$ inches thick.

The welded steel pot chuck weighs 96,200 lb., only 8800 lb. less than its estimated weight in the cast-iron design. The weight could have been still further decreased if the rigidity characteristics of the cast-iron design were only equaled. It was found economical in steel construction to effect not only a medium weight reduction but also to obtain greatly increased rigidity.

The internal gears cut on this pot chuck are made up of six segments, positioned in the chuck on an internal ring shelf. The shelf is welded top and bottom to the inside surface of the main web and rigidly supported by forty-eight auxiliary ribs, closely spaced. These ribs are matched on the outside of the main web by an equal number of ribs running the full depth of the main web, all being $^3/_4$ inch thick plate.

The main outer ring was formed of segments flame-cut and bent. These pieces were $14^1/_2$ inches by 2 inches for the top ring and 26 inches by 2 inches for the bottom ring. When fitted together, these eight segments formed two rings, 33 feet 7 inches in outside diameter. The main ring web of $2^1/_2$ inch thick plate was bent to 31 feet 2 inches outside diameter.

All steel plate entering into the construction of the pot chuck was of special welding quality.

LOADING AND SHIPMENT

For shipment, the two half sections of the pot chuck, each measuring 16 feet $10^1/_4$ inches in height, were loaded on a Pennsylvania Railroad "FN" well type flat car and blocked with 5980 lb. of wood blocking. Clearances and weight were so near to the shipping limits that it was necessary to consider the center of gravity of the load in relation to train speed and safety. The deflection of car springs, due to the load, affected the clearance between the bottom of the load and the rails. The greatest cause of anxiety was clearance with bridges or other wayside structures and the top of the load.

By special arrangement with the Pennsylvania Railroad, the halves of the pot chuck were braced in the well opening of the car with a clearance of only 3 inches from the rail, instead of the usual 6 inches. Clearance under certain overhead structures between the weldery at Coatesville, Pa., and the destination at Camden, N. J., was only 1 inch. Movement was made on special instructions as to routing at close clearance points. Train speed was limited to twenty miles per hour, and instructions given to train dispatchers, yardmasters and train crews to handle the car with extreme care, particularly in yards and around sharp curves.

FINAL OPERATIONS

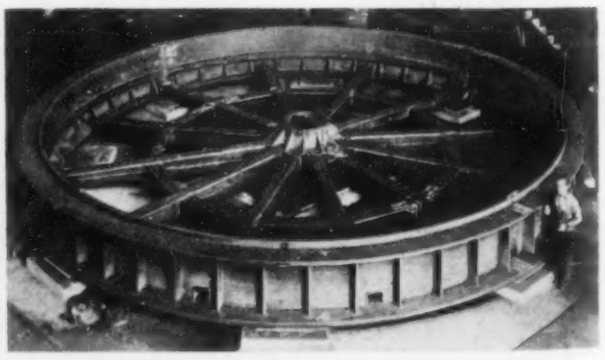
After the pot chuck arrived at the plant of Camden Forge Company, welders and equipment of Lukenweld, Inc., completed the job of assembly and welding in twelve working days.

At final assembly, the ring was found to be out-of-round in an inward direction to an extent of $^3/_8$ inch on each side in the region of the final main joints. This condition meant a reduction in over-all metal thickness of $^3/_8$ inch at the region of the final main joints after machining. Possibly this discrepancy could have been reduced if the pot chuck could have been welded completely at the weldery. However, the discrepancy was considered acceptable by the engineers of Camden Forge Company.

Using the same special furnace designed and built for the heating operations on the internal gear forgings themselves, Camden Forge Company stress-relieved the finished pot chuck in one piece. It was then machined to close limits on the top edge of the main ring and its inside surface down to and including the top surface of the inner shelf. The outside diameter of the top and bottom ring flanges and their top surfaces into the outside ribs were also machined. Approximately $^1/_2$ inch of stock was allowed on all surfaces for machining. Following this operation, the pot chuck will be indexed for the rack teeth to be cut.

The pot chuck and slotter will be placed on a floating foundation to insulate them entirely from all outside vibration. The entire assembly will weigh approximately 1,000,000 lb.

Each internal gear to be slotted will be in six segments, and will be set up on the internal shelf of the pot chuck and bolted in place. The chuck will be rotated on rollers and the indexing accomplished through microscopes mounted on the slotter.



96,200 Pounds of Welded Pot Chuck—Largest Ever Built

PIPE WELDING AT "L" STREET*

Electrical Methods of Preheating, Welding and Stress Relieving Carefully Worked Out—High and Medium Pressure Lines Offer Special Opportunity for Economical Application of Field Equipment

By LEWIS P. GOVE†

FOR the higher pressure and temperature pipe lines of current power plant designs several methods have been used to establish that each welded joint shall be as nearly perfect as possible. The X-ray and the Gamma-ray are used for such investigation, but the cost of these methods is considerable, and unless chill rings are removed from the inside of the pipe false interpretation of the films may result, so that the chipping and rewelding may simply add unnecessary cost. Further, the two walls of pipe are taken on the one film, so that false readings may again be the result.

An alternative method is to make sure that every last detail is completed in strict accordance with the specifications, which means that there must be an engineer or inspector present at all times when there is any welding work in progress, including preheating, stress relieving and applying the hydrostatic test.

For the high-pressure piping systems in the "L" Street station extension of the Boston Edison Company, installed in connection with steam-generation units Nos. 74 and 76 and the No. 12 steam turbine-generator, an inspector of welding was present at all times. He covered the 1300-lb. steam lines, boiler feed discharge lines, intermediate 300-lb. pressure steam lines, boiler blow-off lines and free blow and high-pressure by-pass lines. Steam is generated at 1400-lb. gage and 910° F. total, temperature and the turbine exhaust at 300 lb. gage 625° F. total temperature.

QUALIFICATIONS FOR WELDERS

The welders were certified in accordance with the tentative requirements as adopted by the AMERICAN WELDING SOCIETY and revised in June 1937.

In addition to the certification, a check of each welder was made on the job by having a specimen welded and stress relieved under the observation of the inspector. This specimen was then X-rayed and samples were subjected to tensile and bending tests.

VALVES AND FLANGED JOINTS

The bodies of all valves in the 1300-lb. steam lines and in the boiler feed discharge lines are cast carbon molybdenum steel. All valves in the 1300-lb. steam lines, all free blow and by-pass valves and those in the main runs of the boiler feed discharge and some of the valves in the blow-down lines are welded into the lines. Valves in the intermediate 300-lb. pressure steam lines have cast carbon steel bodies with flanged ends.

There are no flanged joints in the 1300-lb. steam lines except the two at the steam chest on the turbine, which can be classed as an integral part of the unit. There is one exception to this statement. All valves are fitted with bolted bonnets and each of these has a gasket. The control valve and check valve in each boiler feed pump discharge branch have Sargol joints. Also, the boiler feed control valves in each feed line to the boiler have Sargol joints. In addition to these, the joints in the boiler feed lines to the economizer inlets and from economizer outlets to the drums, those in the water column connections, in the feedwater regulator control connections, water level recorder connections, superheater drains, blow-off connections at the drums and water wall headers all have Sargol joints. As a result, the entire 1300-lb. main steam line and the main runs in the boiler feed dis-

* Paper presented before the Nov. 21st meeting, Boston Section, A. W. S., and reprinted from *Electric World*, February 25, 1939 issue.

† Engineer, Mutual Boiler Insurance Company, Boston, Mass.

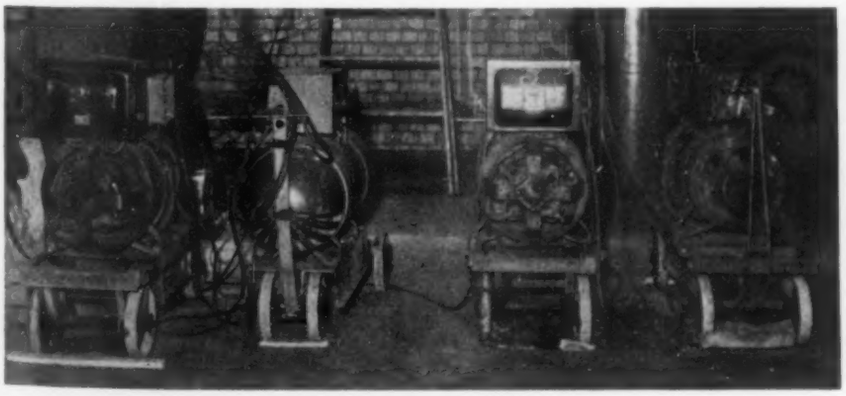


Fig. 1—Battery of Electric Welding Units Used on L Street Piping

Fig. 2—Typical Finished Vertical Weld in 20-In. Turbine Exhaust

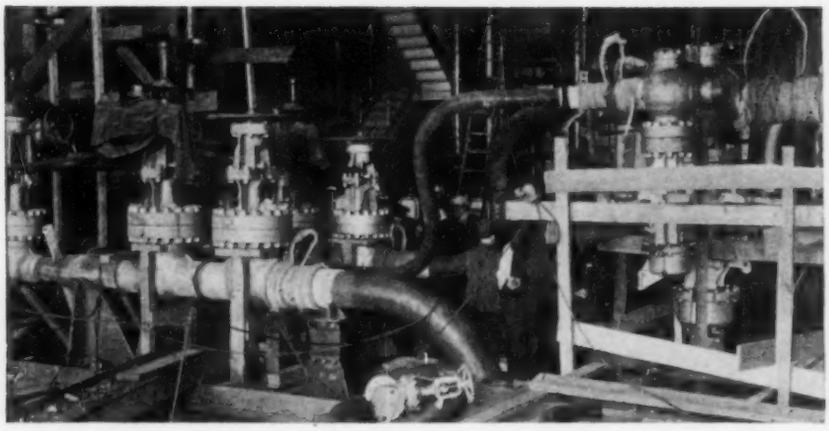


Fig. 3—Main Turbine Lead (14 In.), with 10-In. and 6-In. Branches to Reducing Valves for 300-Lb. Supply, Showing Three Completed Joints and in Left-Center, a Joint Prepared for Stress Relieving

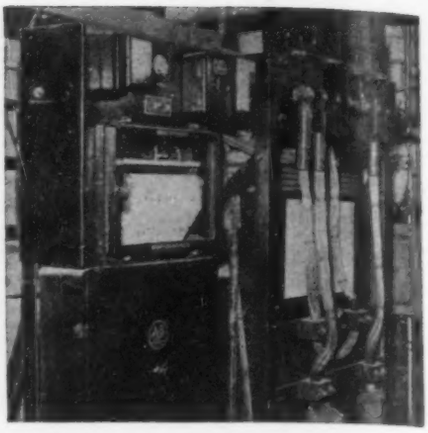


Fig. 4—Control Panel with Pyrometer, Regulator, Transformer and Adjustable Connections for Variable Voltage Application to Preheating and Stress Relieving

Fig. 4—In heating by induction from turns of copper cable wrapped around pipes, valves and fittings, with asbestos paper insulation between coils, extremely uniform results are obtained, temperature control is easily effected by varying the applied voltage and cutting current on or off and overheating is prevented by carbon molybdenum steel becoming non-magnetic between 1350 and 1400° F., so that in such case the transformer begins to draw excessive current, opening fuses or circuit breakers.

charge lines and in the blow-off lines are welded throughout.

The intermediate 300-lb. pressure steam lines have a combination of welded and flanged joints. The 20-in. turbine exhaust to the existing 200-lb. main steam header, the 16-in. cross-connection in the existing boiler room and the 16-in. supply line from the 10-in. desuperheater have welded joints on the runs with gasket type flanged joints at the valves and at a few other connections.

All safety valves are fitted with flanges for gasket joints.

PIPE AND FITTING SPECIFICATIONS

Specifications covering the pipe in the different systems are quoted as follows:

Main steam piping shall be of seamless carbon molybdenum steel pipe in accordance with A. S. T. M. Specification No. A-206-37T with supplementary requirements, normalized and drawn, and of a thickness conforming to A. S. A. Standard Dimensions Schedule No. 160.

High-pressure feedwater discharge piping shall be carbon steel pipe in accordance with A. S. T. M. Specifications No. A-160, with supplementary requirements and A. S. A. Dimension Schedule No. 160.

Intermediate pressure steam lines cover all lines operating at a pressure of 300 lb. This piping shall be in accordance with Schedule No. 30-40, A. S. T. M. Specification A-106, Grade "B."

Blow-off piping shall be from pipe made in accordance with A. S. A. Standard Schedule 80 and A. S. T. M. Specification A-106, Grade "B."

Fittings are forged carbon molybdenum steel for the main steam lines; forged carbon steel for the boiler feed discharge lines; cast-steel in accordance with A. S. A. Standards B-16, 1932, for the intermediate pressure steam lines, and forged steel A. S. A. Standards B-16 and A. S. T. M. Specifications A-95 for the boiler blow-off lines.

WELDING SPECIFICATIONS

All joints were welded with the electric arc method using coated rods. Chill rings of carbon steel were used in lines 5 in. in diameter and larger. They were of the solid type for the pipe with the greater wall thickness and the split type for the thinner walled pipe.

On both the carbon molybdenum steel pipe and the carbon steel pipe the welding procedure consisted of laying an initial bead of shielded-arc electrode in the weld groove. This was to insure good penetration into the chill ring. Welds in the carbon molybdenum pipe were then made with succeeding beads with a special coated rod. Welds on the carbon steel pipe were made in the same way with shielded-arc rod used throughout. Each bead of weld metal was carefully cleaned and roughened after it had been deposited. The inspector was present at the beginning of each weld and checked the weld after each bead had been cleaned and roughened. Each weld was finished with a final heat-treating crown bead laid above the normal surface of the pipe.

Joints between cast carbon molybdenum steel valve bodies and carbon steel pipe in the boiler feed discharge mains were welded in accordance with the specifications for the welding of all the joints in the carbon molybdenum steel pipe.

Joints in the carbon molybdenum steel pipe 6 in. in diameter and larger were preheated with an electric induction unit to a temperature between 400 and 600° F. before starting the weld. The pipe adjacent to the weld was then held at this temperature during the welding process. When it was impossible to complete a weld within the authorized work period the weld was thoroughly wrapped with an asbestos blanket to prevent chilling or sudden cooling.

Joints between the cast carbon molybdenum steel valve bodies and the carbon steel pipe in the boiler feed discharge lines were preheated in the same manner as those on the carbon molybdenum steel pipe.

The carbon molybdenum pipe of the smaller diameter for the free blow and by-pass lines had the joints preheated by gas flame before starting the welds.

On the joints in the carbon steel pipe the preheating was done with the gas flame to a temperature between 150 and 350° F. This temperature was maintained as near as practical throughout the welding of the joint.

STRESS RELIEVING

The specifications stated that all welded joints in steam and water piping sizes 5 in. and larger shall be stress relieved where the service pressure is above 250 lb.

All welds in the carbon molybdenum steel pipe were heated to 1200° F. with the electric induction heater and held there for two hours per inch of thickness. In view of the fact that the 14-in. pipe was 1.406 in. thick, this meant that the heat was held at 1200° F. for three hours for this size joint and for 2¼ hours for the 10-in. pipe, which was 1.25 in. thick.

All welds in the carbon steel pipe were held at 1200° F. with the electric induction heater for one hour per inch of thickness. In both cases heating was followed by cooling to 600° F. through the medium of the electric unit, then allowed to cool in still air to room temperature.

The preheating and stress relieving were applied and controlled by a portable type unit so that the temperature was properly regulated when applying the heat, and also in cooling the joint. All work of installing the unit and the application of the heat was under the direct supervision of the contractor. There were two recording pyrometers connected to the unit, one of which controlled and recorded the preheat temperature and the other one controlled and recorded the stress-relieving temperature. When the work progressed sufficiently so that the stress relieving was getting behind the preheating and welding the preheating unit was converted into a stress-relieving unit which had sufficient capacity to take care of two of the welds of the small diameters. When a joint was prepared for preheating, the electric connections, including the leads for the pyrometers, were arranged so that the one set of connections would serve for both preheating and stress relieving.

RECORDS AND TESTING

The form (Fig. 5) on which inspection of the welded joints was recorded apparently has worked out very satisfactorily. The complete story of a joint from start to finish is covered on one sheet, except, of course, in the event that the stress relieving is delayed a few days after the completion of the weld, when a partial record is made for the later date.

After the completion of the line and after all joints had been stress relieved and cooled to room temperature the line was tested under a hydrostatic pressure of one and one-half times the operating pressure indicated on the valves.

MAN-HOURS PER JOINT

No attempt was made to compare the cost per joint on the welding with flanged joints of previous work. It is yet too early to get a comparatively accurate cost on the "L" Street extension. The contractor, therefore, furnished a set of costs which is considered average taken from field costs of several of their previous installations. These costs, shown in the following table, are given in man-hours so that they may be applied in any community regardless of labor conditions:

Diameter of Pipe	Wall Thickness	Man-Hours Per Joint
6 in.	0.750	16
8 in.	0.906	20
10 in.	1.25	28
12 in.	1.312	44
14 in.	1.406	56
16 in.	0.750	36

The above represents actual field time for welding of carbon molybdenum pipe joints, exclusive of superintendence, handling of the pipe in place, tools, costs of welding energy and home office expenses. It was found that the preheating and stress relieving required an average of 15 man-hours. However, this does not give a true indication of cost, and further investigation brought out the fact that the average cost per welded joint is $27, exclusive of cost of energy, superintendence and general office expense. The remaining item of cost is the inspection, which is approximately $8 per weld. These figures are taken from the tabulation on the "L" Street job and show an average cost per joint where there were two welding crews per joint, so that this particular item may vary considerably, depending on the circumstances.

BOSTON EDISON COMPANY
"L" STREET - STATION No. 4

LINE 2g of 8" SIZE 10 inch DESIGNATION [illegible]
WELDER 331 & 314 WELDER'S HELPER 317 ELECTRODE [illegible]
WELD STARTED 12:30 WELD FINISHED 10:45 BEADS NO. 13
DATE Sept 26,27, 1938 INSPECTION R R Rounds
REMARKS:

PIPE TEMPERATURE

Half-Hour Periods		Original Heat Temp. Deg. F.	Reheat Temp Deg. F.	Stress Relieving Time Started	Stress Relieving Temp. Deg. F.
1.	12:30	455	...	8:00	50
2.	1:00	475	...	8:30	500
3.	1:30	470	...	9:00	900
4.	2:00	450	...	9:30	1020
5.	2:30	475	...	10:00	1200
6.	3:00	550	...	10:30	1200
7.	3:30	560	...	11:00	1200
8.	4:00	470	...	11:30	1200
9.	4:30	450	...	12:00	1200
10.	9:00	...	440	12:30	1170
11	9:30	...	445	1:00	1040
12.	10:00	...	450	1:30	900
13.	10:30	...	405	2:00	780
14.	11:00	...	450	2:30	650
15.	...	...	...	3:00	600
16.	...	...	...	...	...

Fig. 5—Form Used in Recording Data on Electrically Heating Pipe Joints for Welding and Stress Relieving on L Street Station Job

The date, welder's number, the number assigned to the joint, the pipe line, the rod used, the time of starting and completing the weld and the inspector's name are at the top of the form. The preheat temperature and the stress-relieving temperatures are recorded at half-hour intervals. In a case where the joint cannot be welded completely during the regular work period the repreheating is also recorded

WELDING HANDBOOK

The supply of this 1200 page authoritative book on welding is nearly exhausted. Members are urged to purchase such quantities as they need before it is too late. Price to members extra copies $5.00. Price to non-members $6.00 in U. S. A., $6.50 elsewhere

WELDED HIGH PRESSURE PIPING*

By ARTHUR N. KUGLER†

THE term high pressure as applied to piping is subject to many interpretations. To one installing heating system where 5 to 10 psi (pounds per square inch) is a common pressure range, 100 psi is high pressure. On the other hand this pressure would be considered low by a stream power plant or refinery operator with whom 900 to 1100 psi and up to 1000° F. are not uncommon conditions today. What then is the criterion for determining high pressure? At various times definite pressures have been arbitrarily chosen as the point of division. Such points have been 100 psi, 250 psi while today 450 psi is generally accepted. However, this question can be approached from another angle, namely, pipe wall thickness which factor more directly influences the welding technique. Pipe wall thickness is governed by operating conditions, that is pressure and temperature. Another factor that sometimes affects the thickness is the presence of corrosive conditions. Standard specifications governing the selection of proper thicknesses will be found in the American Standards Association Code for Pressure Piping and The American Society for Testing Materials Specification A106–36. For the purposes of this discussion pipe $^1/_2$ inch thick and greater will be considered high pressure piping.

Since pipe wall thickness is the one element, other than steel analysis, which has a marked influence on welding technique, its relation to the procedure should be studied carefully. However, before making this study we should know something of the methods of testing pipe welds to evaluate the relative physical properties of welds produced by the various methods.

In the current edition of the ASA Code (American Tentative Standard 1935) the welding operators qualification tests provide for testing welds by the familiar reduced section tensile test, the free bend test, the reverse or back bend test and the nick break test. These same tests form an excellent basis for comparing various welding methods. There is, in addition, a relatively new test which no doubt will supplant those enumerated above. This new test known as the restricted or guided bend test has been used for several years by the U. S. Navy Department with excellent results. The bends are made in a jig proportioned in terms of the specimen thickness. The jig consists of a die and plunger which forces the specimens into a "U" shape. When the face or top of the weld is in tension it is known as a "face bend" while with the root in tension it is a "root bend."

The minimum physical properties to be developed on these tests are those given for the operators' qualification. Obviously these minimums should be greatly exceeded in laboratory work to provide for the inevitable variations between laboratory and field conditions. For the reduced section tensile test the minimum requirement is 90% of the minimum specified for pipe material. The free bend test must show an elongation of not less than 15% while the reverse bend test must bend 90° without breaking apart. On the nick break test the fracture must not have more than 6 defects per square inch and no defect may be greater than $^1/_{16}$ inch. The requirements for the restricted bend test are simple and therein lies one of the principal advantages of this test. It is merely that the specimens, both face and root, bend to the full capacity of the jig.

With this background of test methods it is possible to consider better the methods of fulfilling these requirements by oxyacetylene welding. Of all the methods of pipe welding the oldest is perhaps the so-called forehand or puddle welding method. In this the torch and rod are so disposed that the torch flame points ahead of the completed weld and the rod precedes the torch. To produce sound welds it is necessary to give the rod and torch opposite oscillating motions. While it is possible to produce welds meeting the test requirements, it re-

* Presented at the 39th Annual Convention of the International Acetylene Association, Houston, Texas, March 8, 9 and 10, 1939.

† Mechanical Engineer, Air Reduction Sales Company, New York.

Fig. 1—Oxyacetylene Stress Relieving—Multi-Flame Tip

Fig. 2—Oxyacetylene Heated Joint Covered with Asbestos Blocks

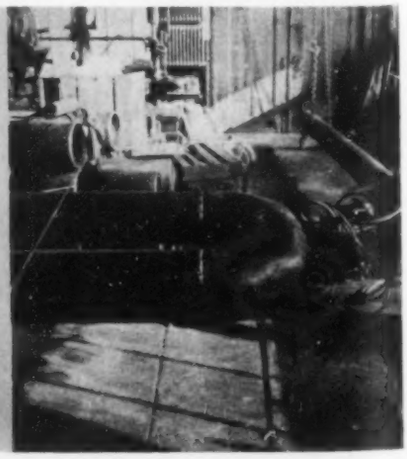


Fig. 3—Completed Weld

quires a high degree of skill. The extensive manipulation of rod and molten metal particularly on heavy wall pipe tends to create porosity with consequent lowering of ductility. The backhand technique also known as carburizing flame welding was developed about ten or twelve years ago. In it the torch and rod are so disposed that the torch flame points back at the completed weld and the rod is interposed between the torch and weld. In this procedure torch and rod manipulation are greatly simplified and further the width of vee is reduced to 70–75°. Welds of this type readily develop 100% the strength of the pipe on reduced section tensile tests. Free bend tests develop 20 to 45% and as high as 55% elongation. Reverse bend tests bend 180° without any sign of failure. Nick break tests showing far less than 6 defects (all within allowable limits) per square inch are standard results while most of the specimens show no defects. The superiority of backhand welding is clearly demonstrated in the restricted bend test where specimens consistently bend to the full capacity of the jig. In all of these tests except the tensile test, forehand welds will show lower values. The tensile strength will be about the same or slightly higher due principally to a lack of ductility.

Backhand welding of the thinner wall thicknesses up to about $^3/_8$ inch is a standard operation with many concerns. In this the weld is made in a single layer, or pass and physical properties noted above are regularly obtained. The welding of pipe greater than $^3/_8$ inch thick in one layer, whether by forehand or backhand welding presents some difficult problems. The principal one is the large puddle of molten metal which must be maintained. On $^3/_4$ inch thick pipe this puddle may be as large as $1^1/_2$ inch to 2 inches in diameter. This large pool of molten metal is created when the operator attempts to fuse the bottom edges of the vee and still maintain proper fusion at the upper corners. True backhand welding reduces many of these troubles to a minimum, nevertheless they are present, tending to reduce welding speed and weld quality. To overcome this, multilayer welding was developed.

Multilayer welding, as the name indicates, comprehends the deposition of weld metal in layers. However, it should not be confused with the somewhat similar arc-welding technique. The layers of the former always bridge from one side of the vee to the other. In the latter, except for the first few heads, the deposited metal does not usually span the vee. Further the thickness of individual layers of multilayer welds will be greater than on arc welds. In general one layer for each one-quarter inch of thickness should be deposited. Thus, for $^1/_2$ inch thick pipe use two layers; for $^3/_4$-inch wall thickness three layers and 1 inch four layers.

Field experience with multilayer oxyacetylene welding indicates savings in time and materials. The economics in welding time are the result of welding on relatively thin layers permitting the operator to devote his attentions to the particular difficulties of that zone. The reduction in welding gases and rods is obtained through the reduced size of puddle carried and the lessened depth of fusion. Over-all cost reductions of 15 to 25% are reported.

Of greater importance is the improvement in weld quality so essential on high pressure piping. The simplification of welding procedure enables average welding operators to make welds which fulfil the test requirements. Tensile strengths equal to that of pipe material are regularly obtained. Free bend ductilities of 25 to 50% and occasionally higher are on record. Back bend tests invariably go 180° without sign of failure. Flawless nick break specimens are the rule. The results on the severe guided bend test are equally gratifying—specimens bend the full capacity of the jig. Thus, we see that for the welding of high pressure piping (heavy wall pipe) multilayer oxyacetylene welding should be used to insure the highest quality at economical costs.

Naturally in a laboratory investigation of a welding procedure many other tests are employed to check results and develop as many physical properties as possible. Among these is the all-weld-metal tensile test. Specimens for this test are machined longitudinally from the weld metal. They are of circular cross section 0.505 inch diameter for the central 2 inches of length and provided at each end with $^3/_4$-inch thread for gripping. The minimum requirements for this test vary with the type of filler material used A. W. S.—A. S. T. M. specification designation A205–37T classifies filler metals by Grade listing the tensile strength and elongation in two inches required for each. For high pressure carbon steel pipe welding in Grades A and B it is recommended that Grade 10 welding rods be specified. Grade 10 rods in the non-stress relieved condition must develop 60,000 psi and 20% elongation in 2 inches. Since the welding of these tests is performed on $^3/_4$-inch plate obviously multilayer welding must be used to meet these requirements.

Thus far, only carbon steel pipe has been considered for the reason that it is more generally encountered. With the recent trend toward higher pressures and temperatures it has become necessary to use steels capable of withstanding these severe conditions. A. S. T. M. specification designation A158-36 list many of the analyses suitable for temperatures of 1100° F. The particular value of these steels is that they possess high creep strengths at elevated temperatures permitting the use of thinner wall pipe than would be possible with plain carbon steel pipe. Thus, we have carbon molybdenum, chrome molybdenum, nickel molybdenum, 18% chromium, 8% nickel and other analyses each suited to some peculiar pressure, temperature or corrosive condition. In general a welding rod of the same analysis should be used for welding these steels.

Carbon molybdenum steel is probably the best known of these analyses since it has been used extensively on the modern high pressure, high temperature steam-electric generating plants. Steam at 900–1400 psi and 900 to 1100° F. is being successfully carried in the so-called "carbon moly" pipe. The analysis of this steel according to A. S. T. M. A158–36 is as follows:

Carbon	0.10–0.20%
Manganese	0.30–0.60
Phosphorus	0.04% Max.
Sulphur	0.05% "
Silicon	0.20–0.50
Molybdenum	0.45–0 65

Most of this pipe installed to date has been arc welded using a specially designed joint. In this joint the ends are upset, bevelled or grooved and bored internally to receive a liner. On some installations oxyacetylene welding has been employed with the same type of joint using a thicker upset section to offset the difference in strength. Due to the long time required to arc weld these joints several piping fabricators have felt that oxyacetylene welding would expedite the operation and yield lower costs. In response to this demand an oxyacetylene welding rod of carbon molybdenum analysis has been developed. It is now undergoing field tests and results are most promising. Since all of this pipe is of heavy wall thickness, obviously multilayer welding is employed along with the backhand technique to insure the highest possible quality.

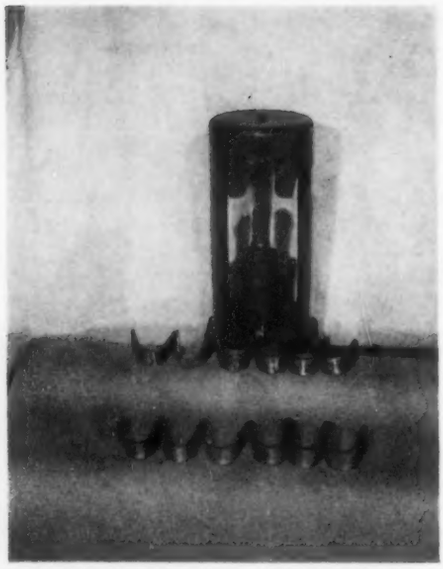


Fig. 4—Guided Bend Test Jig and Specimens
Top-Row Root Bends
Bottom Row Face Bends

A comparison of the arc welding and the oxyacetylene procedures will be interesting. In the former after the prepared pipe ends have been tacked, electric preheating coils are placed around them and the temperature raised to 300–550° F. When the desired temperature is reached welding starts. The preheat temperature is maintained during welding, by elaborate thermocouple controls. Welding progresses with small heads deposited with $^1/_8$ inch and $^5/_{32}$ inch diameter electrodes. It is common practice to chip out about half of each head to insure absence of foreign inclusions. After a weld is completed it is stress relieved by heating with electric coils to a temperature of 1100–1200° F. The rate of temperature rise is maintained at 250° F. per hour. The joint is held at the stress-relieving temperature for four hours per inch of thickness, after which it is cooled at the same definite rate mentioned before. Thus, these welds take a long time—18 to 20 hours for 8-inch joint $1^1/_4$ inches thick—require a large number of beads and consequently the cost is high. Oxyacetylene welding of these same joints including the liner would progress without preheating other than that obtained in the normal operation of the torch. If desired, preheating can be employed using either the electric method or an auxiliary torch. Its use will tend to speed up welding and reduce gas consumptions slightly. However it should be remembered separate preheating is not essential for producing high quality welds. The actual welding proceeds as outlined for multilayer welding with the exception that a greater number of layers is employed, for example, five layers on $^7/_8$ inch thickness. The final layer should always be deposited above the level of the pipe wall surface to insure the maximum heat treating benefits on the previously deposited layers. The stress relieving of carbon molybdenum steel is dictated rather by the steel properties than by the welding technique, hence the same general procedure will be employed for both methods. Stress relieving with the oxyacetylene torch (of which more will be said later) is used by some contractors and offers advantages in economy and speed.

The laboratory test results of these oxyacetylene carbon molybdenum welds indicates that the physical properties of the base metal are readily duplicated. Reduced section tensile tests failures occur in the pipe metal. Free bend test ductilities of 30–40% and over are readily obtained. The reverse bend and nick break tests, which are more tests of the operator's ability than quantitative tests of weld metal, consistently exceed the minimum requirements. The all-weld-metal tensile test specimen develops 65,000 to 80,000 psi and 25 to 30% in two inches. Restricted bend test specimens bend to the full capacity of the jig without any sign of failure. It must be remembered that these results were obtained in the laboratory, where conditions are under close control and not subject to the uncontrollable variables encountered in the field.

An important phase of the procedure for welding of all high pressure piping and one on which we touched briefly in an earlier paragraph is stress relieving. The primary purpose of this operation is to relieve the welded assembly of locked up stresses but in addition it provides a measure of grain refinement all of which is reflected in an increase in weld ductility. The A. S. A. Code requires that welded joints in carbon steel piping shall be stress relieved when the pipe wall thickness is $^3/_4$ inch or greater and the service temperature is in excess of 250° F. The actual heating is carried out in several different ways depending on conditions. In the fabricating shop, furnaces provide the most convenient and economical method of handling the large assemblies. In the field, electric coil units as described previously have found wide acceptance, but are costly. Another field method is to employ small portable furnaces, one for each size of pipe, fired with city or natural gas and air. These have proved very satisfactory on a number of large jobs. Still another field method employs oxyacetylene torches equipped with multiple flame tips. This equipment is used under the standard stress-relieving procedure because of its portability and quickly available high heat. However, on a recent large installation on which stress relieving was specified on extra heavy pipe another oxyacetylene procedure was employed. In this the weld and adjacent pipe is heated uniformly to 1450° F. which temperature is checked by pyrometer. When the joint has reached the desired temperature, heating is stopped and it is wrapped with asbestos blocks or paper, the ends plugged if open, and allowed to cool slowly. Sample welds subjected to this heat treatment were tested by the consulting engineer for the job and engineers for the owner. Results of these tests showed excellent grain refinement throughout the weld area. In addition, weld ductility was materially increased without serious loss in tensile strength. Approval to use this oxyacetylene method was granted on the basis of these tests in spite of the fact that another method of stress relief had been specified.

In actual operation on construction this procedure has proved highly successful and economical. Multiple flame tips and two or more torches on large diameters are used. Recent tests were made of the field welds by trepaning circular plugs from the welds and all showed up excellently when etched.

To sum up, the procedure for oxyacetylene welding of high pressure piping requires first, the selection of a suitable welding technique—Multilayer Welding—second, the use of a suitable welding rod—Grade 10 for carbon steel pipe and rods of the same analysis of the base metal for alloy steel pipe and finally the determination of a proper stress relieving or heat treatment method to insure a minimum of locked up stresses. In this paper we have indicated the current methods of achieving these ends.

REPAIRING A DIESEL ENGINE HEAD

By J. F. GALBRAITH*

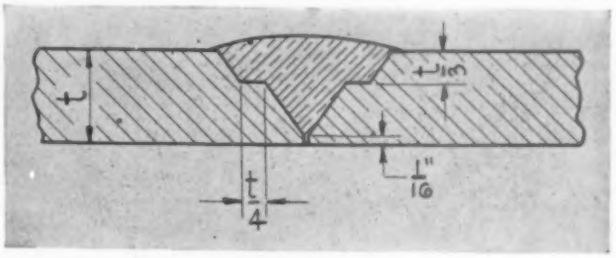
BRONZE-WELDING PROCEDURE SAVES A POSSIBLE SIX-WEEKS' TO TWO-MONTHS' SHUTDOWN

THE value of careful preheating and annealing is well illustrated in the repair of a damaged Diesel engine head which was less than 0.001 in. out of alignment following welding. When this head cracked in service, it was discovered that a new head was procurable only abroad, while efforts to obtain a casting from one of the largest foundries in the vicinity failed. Thanks to bronze-welding, however, the Diesel engine was out of service less than a week—from Sunday until Thursday—and since then it has been operating satisfactorily 24 hr. per day.

PREPARATION FOR WELDING

As can be seen from the accompanying illustration, the cast-iron head is of the jacketed type with four clean-outs and one opening cast purposely for testing. Two cracks had developed in the 30-in. diameter casting, one extending across the outer rim and through the bolt holes. The casting was prepared by chipping, care being taken to see that no sharp corners were left. Any corners which did exist were removed by filing, not grinding.

By Following a Carefully Planned Procedure Control, This Diesel Engine Head Was Less Than 0.001 In. Out of Alignment After Repair by Welding



For Bronze-Welding Cast Iron, This Type of Joint Develops the Full Shear Strength of the Section

JOINT DESIGN

The edges were beveled as a "shear-vee" joint, similar to that recommended for bronze-welding cast-iron pipe as shown in the accompanying sketch. When shearing stresses are encountered, the "shelf" in this design provides for increased bond between the bronze and cast iron and the joint develops the full strength of the section. The strength of a regular vee joint in bronze-welded cast iron, when subjected to shear, varies from 75 to 90 per cent of the strength of the section.

PREHEATING

After the preparation of the joint, the casting was placed in a coke-fired heat-treating furnace, equipped with a pyrometer, and brought to an even temperature of 900° F. Preheating required approximately 1½ hr.

When everything was in readiness, the casting was removed from the furnace and supported with fire bricks on a large steel plate directly in front of the furnace door. Asbestos paper was used as a covering, with an opening just large enough to permit welding.

BRONZE-WELDING PROCEDURE

Commencing at the interior of the break, or the point farthest away from the rim, welding proceeded until the larger of the two cracks was completed. The casting was then reheated in the furnace, and the smaller of the two cracks was welded in a similar manner. Approximately 15 lb. of bronze rod and ¼ lb. of flux were used for the repair, while the total time for welding was 3 hr.

After the completion of the welding operation, the head was replaced in the furnace and cooled slowly by letting the fire die out gradually. When the casting was subsequently chucked in a lathe, it was found to be less than 0.001 in. out of alignment.

* The Linde Air Products Co.

3% NICKEL INCREASES LIFE of Trackwork

By H. L. LEWIS*

AUSTENITIC MANGANESE STEEL

THE austenitic manganese cast steel, containing 10–14% manganese (named Hadfield's steel, from its discoverer) has certain desirable properties that have made it an important material for many applications requiring resistance to abrasive wear. But the welding of this steel, owing to the damage of the parent metal near the weld caused by the welding heat, was impractical until the development in recent years of a manganese-nickel steel welding electrode, in which 2 to 5% nickel was added, and the normal carbon content reduced.†

NICKEL PREVENTS CARBIDE FORMATION

By adding nickel to austenitic manganese steel, it has been found that the carbon can be lowered, and the steel still retains its austenitic structure. This lessens the tendency for carbide formation along the critical-heat line in welding, and hence solves the problem of fusion welding.

The success of this steel in welding rods has led to its use for both cast and wrought parts where weldability and improved general properties are demanded in addition to the primary quality of abrasion-resistance for which the original Hadfield steel is noted. It has been employed satisfactorily in rolled applicator bars for welding onto worn-down shovel dipper teeth, crusher plates, etc., and for building up worn trackwork. A logical consequence is the production of castings in this composition for such purposes, two examples of which are described below.

WELDING FROGS

Two solid turnout frogs cast in a composition containing approximately 0.85% carbon, 13.80% manganese, 1.00% silicon and 3.50% nickel,‡ were installed late in 1934 at the busiest location in the Chicago yards of the Chicago, Milwaukee, St. Paul & Pacific Railroad, where the most severe service is encountered. These frogs have stood up excellently during this four-year period, being maintained by welding periodically without removal from the track.

This service being highly satisfactory, two later installations were made in crossings for the Milwaukee Road, in which one end frog and one center frog were of the manganese-nickel composition, the other end and center frogs being of standard 13% manganese steel, as a test installation designed to give a definite comparison between the straight manganese steel and that with nickel added, since the same traffic would have to pass over both crossings. After two years' service for these composite frogs, Mr. C. E. Morgan, Supt. of Work Equipment and Welding, writes: "We have found no cracks in the manganese-nickel trackwork, and this, with its adaptability to maintenance by welding, seems to make it superior to the Hadfield steel."

Interesting additional data is found in the experience of the Texas and New Orleans Railroad (Southern Pacific System) with 47 self-guarded manganese nickel steel frogs which were used in the original construction of the terminal yards at Avondale, Louisiana, and on various other track changes and additions in the New Orleans terminal in connection with the provision of facilities required to make use of the new bridge across the Mississippi River. These castings have been in regular service since the new facilities were put in use during the latter part of 1935. This railroad reports that their performance has been highly satisfactory, with no failures, and that the wear in this three-year period has not as yet been sufficient to warrant restorative repairs by welding or otherwise. They are giving far better service than could be expected from the ordinary type of bolted rail frogs.

* Nickel Steel Topics.

† This manganese-nickel steel, known as "Manganal," is produced under the patents of the Stulz-Sickles Co., of Newark, N. J. Typical properties of the castings, after a normalizing and drawing heat treatment are:

Tensile Strength lb./sq. in.	155,000
Yield Point lb./sq. in.	60,000
Elongation in 2 inches	35%
Reduction of Area	35%

‡ Average composition range for standard Hadfield steel is 1.00/1.40% carbon, 10/14% manganese, under 0.50% silicon.

SEVEN WAYS TO GREATER ACCURACY*

THESE COMMON FAULTS IN MACHINE-CUTTING TECHNIQUE ARE EASILY REMEDIED

ALTHOUGH there are a number of variables which affect the economy and efficiency of oxyacetylene machine-cutting and the quality and accuracy of the cut edge, there is one quick means for determining whether or not correct techniques are being employed. This is by an examination of the cut surface.

STUDY ILLUSTRATIONS ON FOLLOWING PAGE

Seven of the illustrations on the following page show what happens when incorrect practices are followed. By studying these cut surfaces and comparing them with that shown in the top photograph, the cutting-machine operator will be in a better position to determine quickly ways and means for obtaining maximum results.

* Reprinted from March 1939 issue *Oxyacetylene Tips*.

1. **Correct Cutting Technique.** The surface is plane and regular, and the drag lines are practically vertical. The slight amount of adhering scale at the top of the cut due to the action of the preheat flames can be easily chipped off. This is an excellent surface and for many purposes can be used without machining.

2. **Cutting Speed Too Low.** Here there is an extensive undercutting and adhesion of molten slag resulting in an extremely irregular surface. Also, with too low a cutting speed, there is an undue waste of oxygen and acetylene.

3. **Cutting Speed Too High.** Excessive cutting speed is shown by the angle of rake of the drag lines. Nevertheless, the surface is reasonably smooth and for normal production work would be satisfactory. However, there is danger of losing the cut, if the speed is increased above that indicated by this photograph.

4. **Nozzle Too Far from Work.** This results in excessive melting of the top edge. When cutting at normal speed and with correct nozzle clearance, the preheat flames should be in contact with the plate surface. At greater clearances, the heat is drawn in by the aspirating effect of the oxygen stream.

5. **Nozzle Too Near the Work.** In order to prevent popping of the flame, an excessive preheat flame has been used. A portion of the preheat cone burns inside the kerf, resulting in an unstable cutting action. This produces grooves and exaggerated drag lines.

6. **Excess Cutting Oxygen.** The combustion of steel follows the pattern of the oxygen stream. For a given nozzle size, excess oxygen consumption is caused by excessive oxygen pressure which, in turn, causes excessive expansion immediately below the orifice. This results in a distorted and unsightly cut.

7. **Excess Preheat Flame.** Inexperienced operators frequently endeavor to speed up the cut by using an excessive preheat flame. This does not affect speed of cutting, but merely serves to fuse the top edge of the metal. In addition, there is an unnecessary waste of gases.

8. **Dirty Nozzle Used.** The nozzle here has been fouled by some adhering scale with the result that the oxygen stream has lost its parallel form and the surface of the cut is no longer clear and regular. There is evidence of pitting, undercutting and excessive scale. This can be remedied by cleaning the nozzle.

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Reminiscences in Connection with Design of the First All-Welded Steam Power Freighter*

By JAMES G. DUDLEY†

IN JUNE 1917, I was retained by W. A. Harriman as head of the Research and Experimental Department for his two (War) shipyards at Chester and Bristol, Pennsylvania.

My chief was Mr. W. T. Smith, former vice-president of the Thompson Starret Company and was himself well informed and an ardent advocate of electric welding.

My Associate engineer was the noted electrical engineer, Mr. Walter J. Jones who no doubt, is known to many of the members of the AMERICAN WELDING SOCIETY, since he was a charter member of the Welding Committee of the Emergency Fleet Corp. and also one of its Research Committee.

Mr. W. T. Bonner, also a member of the Society and a noted mechanical engineer was in charge of the welding construction departments of our two (Harriman) shipyards.

During 1917, we were welding at the Chester Yard practically every part of our standard 8800 ton (freighter) ships which was then permitted by Lloyds inspectors and the American Bureau of Shipping.

In October of 1917, I made an address before the Builders Exchange of Philadelphia and my plea to America was to turn loose the pent-up energies of our American Engineers in their zeal to speed up the shipbuilding program, to be chiefly gained by the substitution of electric welding in place of riveting.

This address led to an examination by three welding experts of the special ships parts which we were then actually incorporating into our ships.

As a result of a favorable report to Admiral Bowles of these welding experts, there was at once created the Welding Committee of the Emergency Fleet Corp. to give Governmental endorsement to, and to speed up, research into the special problems involved in the greater use of electric welding in our (War) ship-building.

Along with many others, including my Research Associate, Mr. Walter J. Jones, and our Welding Engineer, Mr. W. T. Bonner, who incidentally had already designed and constructed a number of barges at Newburgh, New York, I was made charter member, and a member of the Research subcommittee of this Welding Committee of the Emergency Fleet Corporation.

As no doubt you all know, when the World War was brought to a close, the activities of this Welding Committee of the Emergency Fleet Corp. were merged into the AMERICAN WELDING SOCIETY.

Just before Thanksgiving Day, 1918, the Harriman executives, as the result of the march of (welding) events inside and outside our Chester Yard, officially authorized our Research and Experimental Department to: prove out on paper at least, our oft-repeated claims of the gains to be made in the translation of one of our standard 8800 ton (steam) welded freighters into its all-electric-welded counterpart.

In order to lure us on in that great essay, we were assured that in the event that we should so prove out our claims, then one (specific) shipway at the Chester Yard would be set aside for actual construction under our research department design and supervision.

As great a problem next developed, to wit: How to demonstrate to the yard riveting technicians just what our new fabrication technique involved.

A plan was proposed to execute the scale model in clear glass with ruby glass seams to show the welds. In short, a true X-ray or phantom model.

The research department (in camera)—all and sundry—endorsed the glass model concept 100%.

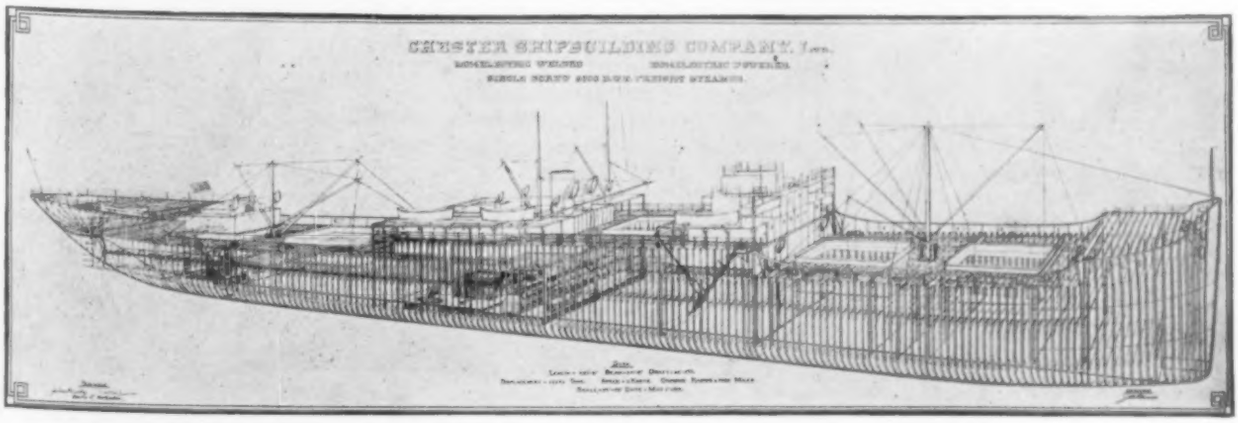
"But," said Artist John Mason, a temporary and non-technical newcomer, "I can draw that ship to show all you wish for the glass model."

When the answer, "surely," came to my every inquiry as to: "Made to scale of 1/4 inch? True aerial perspective? Inclusion of power plant? Phantom hull? etc., etc.," I finally capitulated on learning that John Mason had had his pictures hung in Paris Salons—a fact before unknown to any of us.

And so it was that after more than six (6) months this marvelous drawing which I show you of what I verily believe, was the first ocean-going all-welded, electric powered, design ever to be 100% translated from a riveted counterpart, was finally completed about May 1, 1919.

The original drawing, 9 feet long by 3 feet high, has, sad to relate, been "sunk without trace" in the twenty (20) years that have elapsed since its birth!

*Presented at March 7th Meeting, New York Section, A. W. S.
†Consulting Engineer.



OXYACETYLENE SHAPE-CUTTING of Oil Field Equipment Parts*

By L. W. STAHL†

THE petroleum industry has for years been one of the most rapidly expanding industries in our national business picture. With its growth it is meeting and conquering new problems incident to deeper production and exploration of remote territory, both domestic and abroad. To meet such problems, the manufacturers of machinery used in drilling for and production of oil are ever hard pressed to answer the demands of the operating companies. To this end, steel fabrication is called upon to play a most important rôle. Such fabrication, in turn, employs welding and gas cutting to the utmost and the success of the completed structures and their cost of production depend to a large measure upon these processes.

Our company, with plants in Houston, Texas and Los Angeles, Calif., is a manufacturer of oil field machinery and equipment. It is our business to design and produce such machinery of the very latest type and our endeavor to keep ahead of the operators by anticipating their needs. To do this, we must constantly press our research and engineering departments in the search for new ideas and methods of manufacture. One very natural avenue toward such ends was the introduction into our plant of oxyacetylene shape cutting, using an oxygraph machine. It is with a few of our uses of this process that this paper will deal.

We base our manufacture upon the fabrication of machine parts, so far as that type of construction becomes economically possible. This for the reason that by so doing we can offer our customers equipment having all of the strength, light weight and other desirable characteristics of steel as compared with conventional cast-iron construction. Such equipment has also the quality of being readily repaired in the field with a welding torch or arc machine instead of costly iron replacements. The matter of light weight is probably more important to operators on foreign work or in remote locations than is that of first cost. This latter is, of course, also favored by welded design. We naturally find that there is always a point where fabrication must leave off and the use of castings begin. This means then that we must frequently join fabricated members to steel castings through the medium of welding.

In the foregoing type of work, we make two principal uses of the oxyacetylene cutting machine. Other than where standard structural shapes are cut and welded, we employ quantities of steel plate in all thicknesses up to 6 inches. Innumerable shapes must be cut from these plates and usually they are jointed either to structural shapes or to steel castings or to both. Where a sufficient quantity of any one item is to be used, a template is made and job of cutting is referred to the oxyacetylene cutting machine. The greater number of the parts so formed are cut from plates running $1/4$ inch to 1 inch in thickness. We rarely make use of the "stacking" process since our work is generally of thicknesses warranting individual cutting and we find that the set-up time required for stacking is not justified. Much of our fabrication requires the fitting together of cut plate shapes and structural elements within dimensions closer than standard mill tolerances. This means that we frequently cut three or four sides of square or rectangular plates instead of endeavoring to utilize plate in mill strips or universal plate, with possibly $1/8$ inch or more plus or minus tolerance in width. Once our template is made and checked to produce the desired fit, we know that all pieces cut from it can be relied upon to assemble within the required limits.

Fig. 1—Pumping Unit Crank

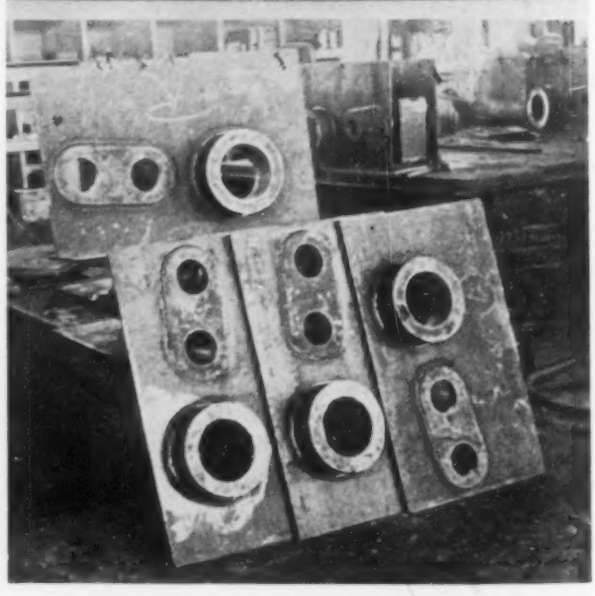
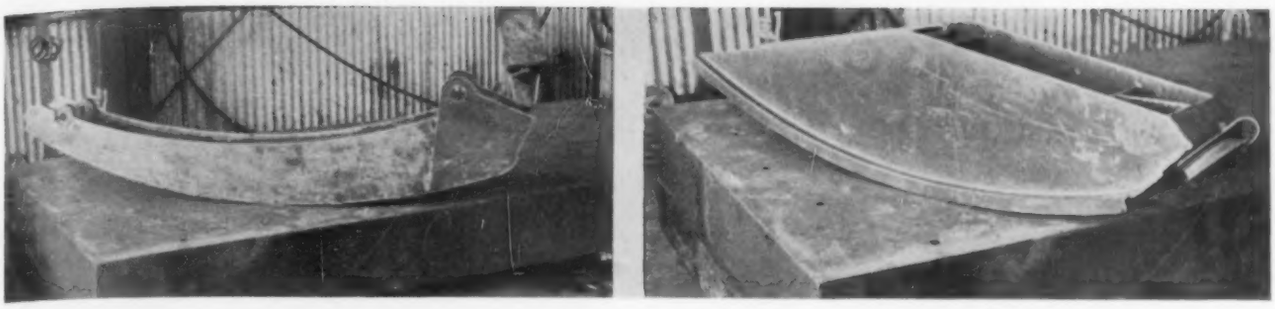


Fig. 2—Side Walls for Pumping Unit Gear Case

* Presented at the 39th Annual Convention of the International Acetylene Association, Houston, Texas, March 8, 9 and 10, 1939.

† Plant Manager and Chief Engineer, Emsco Derrick & Equipment Company, Houston, Texas.



Hanger Type Horsehead

Fig. 3—Pumping Unit Walking Beam Head

Our other great use of the oxyacetylene cutting machine is in the forming of parts from heavy plate. Many of these parts when finally machined take the place of steel castings. They are produced quickly and at will, are cheaper (the stock costing around 2.7 cents per pound as against 10 to 20 cents for steel castings), and only inexpensive templates are needed instead of casting patterns. Such parts are also found to machine more freely than do castings and porosity, holes and sand inclusions are not met with. In fact, we "cast" quantities of our simple designs upon our cutting machine.

Again, we find that frequently where we would employ steel forgings we can save money by cutting rings and other simple shapes from plate, thus expediting the job by time required for ordering, making and delivering the forgings. The stock of heavy plate that is necessarily carried to handle such work is much less expensive and is much more flexible as to what may be made from it than would be a comparable stock of castings and forgings for making similar items. We can frequently cut out objects on the cutting machine that are sufficiently smooth on the cut surfaces so that when welded into an assembly it may be unnecessary to machine some surfaces where the ordinary forging would present too rough or irregular an appearance. Example of this will be covered later.

It must be borne in mind that as fabricated construction and the use of machine torch cutting are applied to manufacture it is imperative that the equipment being manufactured must be designed with particular attention to and knowledge of the shop problems attendent thereto. Proper allowances for shrinkage, warpage and the effects of heat upon metal structures need be made by the designing engineer. It becomes very necessary that the designer work in close cooperation with the shop, since after all it is there that the designs and theories are put into practice. We often find that even our best engineers sometimes overlook or are ignorant of shop difficulties to be encountered. We also find that our shop men do not always display the wisdom of the sages. All of which indicates that thought, knowledge and experience must combine to design and produce material by the methods we are here considering. Many a costly lesson may be learned through over-zealous employees.

Now to get on with particular applications that we make of oxyacetylene machine cutting, I shall enumerate and describe briefly as follows: (1) Pumping Unit Cranks, (2) Pumping Unit Gear Case and Its Side Wall Construction, (3) Pumping Unit Beam Hanger and Horsehead, (4) Slush Pump Side Wall Plates, (5) Renewable Sprocket Rims and (6) Miscellaneous other parts.

(1) *Pumping Unit Crank.*—This part directly replaces cast-steel or cast-iron construction and requires no more machine work to complete it than would the cast pieces. The particular crank shown is cut from $3^1/_2$-inch plate. Two settings are necessary to obtain the contours in two planes. Two simple templates guide the magnetic tracing finger of the oxygraph with two cutting torches operating simultaneously and cutting two identical designs. These cranks are always cut in appreciable lots so as to maintain a low average cost. The first operation cuts the outer contour of the crank from the flat plate. The second is performed on each pair of cranks with them held on edge in a fixture so that the cut is made through the material the thick way. This slicing operation removes material between the hub and the end, thereby producing a contour similar to a casting in appearance. The weight of the crank as it leaves the machine is 84 pounds. This added to the scrap makes a total of 118 pounds of plate used for each crank at a material cost of 2.7 cents per pound. With the labor and shop overhead, the piece so far represents a cost of $5.19. A steel casting could be cored to reduce the weight to 74 pounds which at 11.4 cents per pound gives a cost of $8.44. A saving of $3.25 each is made on the cranks and the same subsequent machine operations are required to finish both casting and cut piece (Fig. 1).

(2) *Gear Cast and Side Wall Construction.*—The pumping unit upon which the above crank is used has a fabricated gear case for a train of double reduction gears. This case is in turn welded into a fabricated base frame for the unit. The case is completely fabricated with the exception of its cast-iron cover. Here we found that a simple cast-iron cover can be made cheaper than a fabricated one. The top of the cover is curved and bears large cast letters upon it. The box proper is built up from five plates; two side walls, two ends and a bottom, all of $^3/_8$-inch material. Small stiffeners, lugs, etc. are also added. Due to the fact that this box when completed must be accurate in dimensions and must fit into the base frame, we have found it advisable to cut the

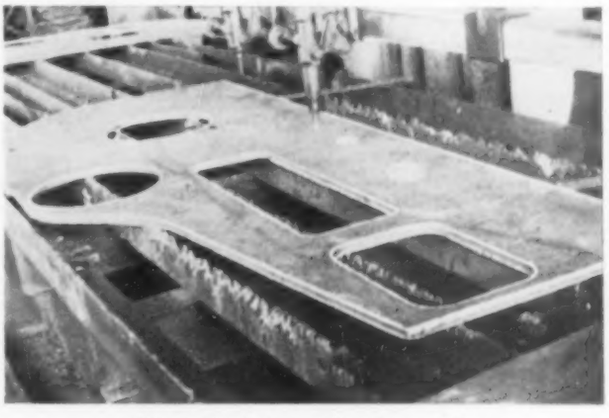


Fig. 4—Slush Pump Side Frame Plate

plates on three or four edges, as plate mill tolerances are not adequate. One set of templates guarantees our dimensions. It is the side wall of the box that draws our particular attention. At the time the plate is set for contour cutting, two openings are cut for the insertion of bearing mountings for the three shafts of the gear case. The bearing mountings are also machine cut from heavy plate. They are welded into the side wall before that part is placed in the box assembly. As we have no cast case of this size or type, I cannot present comparative costs. We do know, however, that the two sizes of case that we make in this manner are cheap, light and very satisfactory.

(3) *Pumping Unit Beam Hanger and Horsehead.*—We now show you two types of pumping unit walking beam head (Fig. 3). One is a hanger type and one a horsehead. Both are completely fabricated with the exception of a small steel casting welded into the top of the horsehead. The side plates of both types are machine cut jobs.

(4) *Slush Pump Side Frame Plate.*—We build several sizes and types of mud or slush pumps for circulating the mud-laden fluid used during rotary drilling operations. Two of these pumps are of the power, or gear driven type. The power ends of these are fabricated from plates, shapes and some steel castings, many of the pieces being oxyacetylene cut products (Fig. 4).

The side wall of the power frame is a one-piece job done on the cutting machine. The complete contour of the plate together with openings for the doors and for the cast-steel bearing housings are cut from one template. The plate is $^{5}/_{8}$ inches thick. Torch cutting of these plates by hand would be the only other method of producing them. The saving through use of the machine cutting is evident, to say nothing of the uniformity of the product.

(5) *Renewable Sprocket Rims.*—Another item of which we manufacture a very considerable quantity is a renewable sprocket rim. The oil industry uses innumerable chain drives, particularly upon the hoist or drawworks of a drilling rig. The sprockets for the drives of this type are generally of cast steel though some are fabricated. Even though the teeth may be machine cut and hardened, the service is extremely severe and in time either the sprocket or its tooth rim needs replacing. We have developed a nice business in rim replacements on worn sprockets. The old rim is cut from the hub or hub flange and for a given size sprocket the flange is machined with a step cut to a given standard diameter that we have set up. A new rim with machine-cut, hardened teeth and a step-cut bore is fitted to the old part and welded into place. The result is a new sprocket, to all intents, at a saving in cost of the hub and flange section. Another advantage is that the size of a sprocket, new or used, may be changed by this method. The manufacture of the renewable rims is of interest to you. A large stock of sprocket templates, for all sizes and numbers of teeth is kept on hand.

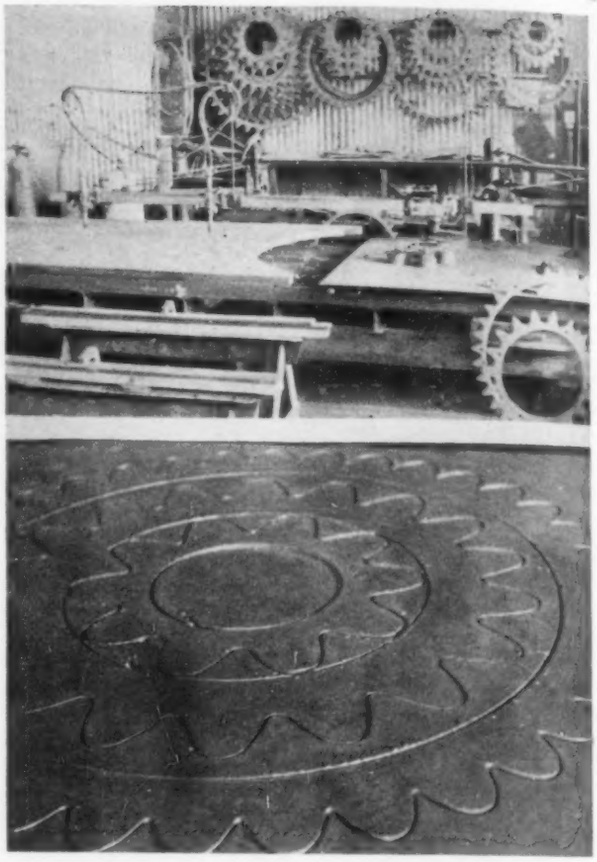


Fig. 5—Renewable Sprocket Rims—Flame-Cut

By the use of these, the machine cuts the complete contour from plate stock, to relatively close machining dimensions, even including the bore for the hub fit. Here the cutting machine is an indispensable adjunct to this job. One might question why we do not cut even more closely to the finish contour of the teeth. We have found that the contour as used permits the cutters of the tooth forming machine to attack the metal at a point a little back from the cut edge, thus preventing rapid dulling of the cutters. An interesting possibility of nesting this type of work is presented where sprocket rims of several sizes may be cut, one with the other and one setting, thus reducing the scrap loss and also set-up time.

ANNUAL MEETING!

Chicago, Illinois—October 22 to 27, 1939

Headquarters—American Welding Society—Stevens Hotel

In Conjunction with National Metals Exposition

15 Technical Sessions—60 Papers

Entertainment, Latest Developments, Get-together Meetings, Committee Meetings

Record Attendance expected. Plan to be there

Welding Society ACTIVITIES—Related Events

LINCOLN GOLD MEDAL AWARD

The Lincoln Gold Medal Award is awarded annually for the best paper presented before a Section or National Meeting of the Society and published in THE WELDING JOURNAL. The Executive Committee of the Society at a meeting on March 23rd acted favorably on a suggestion of the Board of Award to change the period for which the award is applicable. The revised rulings read:

"For the author or authors to be eligible for this award, the paper shall have been published in an issue of THE WELDING JOURNAL during a twelve-month period ending with the July issue before the Annual Fall Meeting, and also, the paper shall have been presented or scheduled for presentation either at a meeting of the AMERICAN WELDING SOCIETY or a meeting of any division or section of the Society.

"The Lincoln Gold Medal Award for 1939 shall be based on papers appearing in an issue of THE WELDING JOURNAL beginning with the November 1938 issue and ending with the July 1939 issue.

Notification of Award

The Board of Awards shall make known its selection of Prize Winners each year by September 1st to the Executive Committee of the AMERICAN WELDING SOCIETY for formal approval. The Prize Winners shall be directly notified by the Secretary of the Society."

EIGHTH ANNUAL WELDING ENGINEERING CONFERENCE, THE OHIO STATE UNIVERSITY

Program for this Conference is as follows:

Thursday, May 11th

"Structural Welding"—E. W. P. Smith, Lincoln Electric Company.

"Welded Tanks"—H. C. Boardman, President, AMERICAN WELDING SOCIETY.

"Structural Steel Welding in New York City"—A. N. Kugler, Air Reduction Sales Company.

Dinner Meeting of the Columbus Section of the AMERICAN WELDING SOCIETY at the Fort Hayes Hotel—7:00 P.M. Followed at 8:15 P.M. by:

"Unionmelt," a motion picture of this new welding process, presented by E. E. Radcliffe, The Linde Air Products Company.

Friday, May 12th

"Designing and Welding Large Machines"—A. E. Gibson, President, Wellman Engineering Company.

"Surface Hardening and Hard Surfacing"—C. E. MacQuigg, Dean, College of Engineering, Ohio State University.

"Oxy-Acetylene Cutting and Treating Processes Applied to Welded Fabrication"—Roger B. White, Lewis Welding and Engineering Corporation.

"The Engineering Aspects of Resistance Welders"—S. M. Humphrey, Chief Electrical Engineer, Taylor Winfield Corporation.

The Exhibits of Welding Equipment by over twenty manufacturers will be open on the following hours: Thursday, May 11th, 9:00 A.M. to 1:30 P.M. and 5:00 to 6:30 P.M. Friday, May 12th, 2:30 P.M. to 10:30 P.M.

Two 18-foot Welded Steel Trusses, furnished by the Truscon Steel Company, are to be tested to destruction between 2:00 and 5:00 P.M. Friday.

Members of the AMERICAN WELDING SOCIETY are cordially invited to attend the Conference. Correspondence should be addressed to J. R. Stitt, Chairman, Welding Engineer Conference Committee, The Ohio State University, Columbus.

WELDING CLINIC

A welding clinic has been scheduled for May 5th and 6th at Williams & Company, 901 Pennsylvania Avenue, Pittsburgh. Mr. F. G. Flocke of The International Nickel Company, Inc., will handle nickel and nickel alloys. The Aluminum Company, The American Brass Company, and others will cooperate. The clinic will also mark the opening of Williams' new Pittsburgh warehouse.

STEEL YACHT TO SERVE AS HOME

Chauncey Parsons, of New York, beamed as he planned life aboard the Vagabond, an all-welded steel sailing yacht launched yesterday at the foot of Caroline street.

Mrs. Parsons, wife of the owner-designer of the forty-foot yawl, officiated. She smashed a bottle of champagne against the bow and christened it by the title with which the residents of Port Washington, L. I., the home port, will come to know it.

First Of Kind Built Here

A departure from the conventional wood plank-by-plank construction of small pleasure craft, the Vagabond has sides of two pieces of sheet steel running the full length. Two similar sections form the bottom, being joined to the side pieces at a single welded edge. Steel ribs welded to a one-piece keelson complete the all-metal construction.

Piano To Be Installed

As Mr. Parsons admitted, his wife made several reservations before agreeing to make the yawl her home—in New York waters in summer and Florida during the winter. One of them was a piano; a thirty-two-inch one will be installed.

To Be Rigged For Cruise

The cabin is to be divided into two staterooms and will accommodate four on permanent bunks. Pipe and transom berths will take care of three more. Bathroom and galley are to be arranged between the fore and after staterooms. A four-cylinder marine engine will provide auxiliary power.

After the launching, the Vagabond was towed to a Rock Creek boat-building plant to be rigged for the cruise to Port Washington.

UMBRELLAS

Four huge stainless steel umbrellas, each large enough to keep the rain off 2150 persons, will shelter the outdoor exhibit of the Edward G. Budd Manufacturing Company at the New York World's Fair.

Each "parasol" will be sixty feet in diameter, yet will be designed so ingeniously it will be relatively light in weight, effectively demonstrating the use of stainless steel where great strength, yet light weight, is required.

A central figure will be the largest weather vane ever built—its shimmering stainless steel mast rising ninety feet into the air, with an 80-foot wind direction indicator at the top.

Beneath the spreading umbrellas will be located a group of exhibits to show Budd's contributions to the metal working industry and to transportation during the past 25 years.

Visitors will be shown how streamlined trains are built and cars from these trains will be located on tracks near the exhibit.

The exhibit was designed by Voorhees, Walker, Foley and Smith, architects.

MACHINE TO HARVEST SUGAR CANE IS SHIPPED TO HAWAII

Native sugar cane cutters in Hawaii will stand awestruck when this monster cane harvester starts gobbling up stalks of cane like some starved mammoth which has chanced upon a field of particularly luscious grain.

This giant—compare its tire (7 feet diameter) with the truck in Fig. 3—started its journey recently to Hawaii where it will be put into operation by the Honolulu Sugar Planters' Association. Built as an experimental unit, the harvester will be "field-engineered;" any changes proved necessary by operating trials will be made by means of the truck shown in Fig. 3 which is a traveling fabricating shop fitted with arc-welding equipment, driven by power take-off from the truck drive shaft. The arc-welding truck, which makes it possible to weld new structural parts for the harvester—right in the field

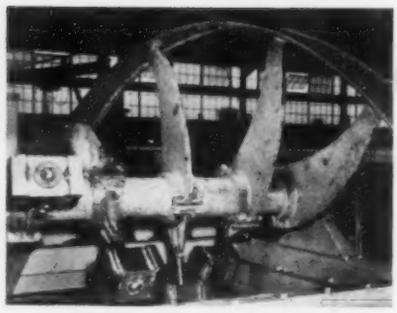


Fig. 1—Arc-Welded Cutting Mechanism of Sugar Cane Harvester

Photos Courtesy The Lincoln Electric Company, Cleveland, Ohio

of sugar cane, if necessary—will accompany the machine until all mechanical or structural "bugs" are ironed out and the harvester is acclaimed successful.

The sugar cane harvester was built for the Honolulu Sugar Planters' Association by R. G. LeTourneau Inc., Peoria, Illinois. It has been in process of development for many months. The idea for it grew out of a discussion of cane harvesting problems between Hawaiian cane growers and R. G. LeTourneau when the latter was in Hawaii some time ago.

In constructing the harvester, R. G. LeTourneau Inc. employed the manufacturing process which it uses exclusively in its production of heavy earth moving equipment. This process is arc welding. Because of its simplicity and flexibility, and because of its structural benefits, arc welding made construction of the harvester possible, according to R. G. LeTourneau.

The cane harvester will cut the cane just below the surface, yet high enough to avoid injury to the roots. As it cuts the cane, the machine will pick up the stalks, take them into its cutting compartment, cut them into pieces approximately a foot long, then carry the pieces by conveyor mechanism to trucks or wagons which will travel along beside the harvester. A view of the cutting mechanism can be seen in Fig. 1. Figure 2 shows the complete machine as it will be tried out in Hawaii.

The engine installed in the harvester is a 160-horsepower Diesel built by Caterpillar. The large generator mounted on the front of the engine (see Fig. 3) is for the purpose of furnishing power to electric motors which drive the conveyors, etc.

This huge piece of machinery is successfully operated by only one man.

Fig. 2—Sugar Cane Harvester Shipped Recently to Honolulu, Hawaii

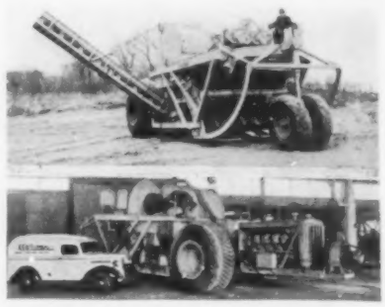


Fig. 3—The Complete Sugar Cane Harvester as It Will Be Placed in Operation by the Honolulu Sugar Planters' Association

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You are cordially invited to visit the Bell System exhibit at Golden Gate International Exposition, San Francisco

CLEVELAND'S NEW MAIN AVE. BRIDGE TO OPEN JUNE 30TH

Cleveland's new $7,000,000—6-lane, 1½-mile-long Main Avenue bridge, being built to relieve traffic congestion in and out of the city over the Cuyahoga River on the west side, will be open June 30th, according to a statement released by the office of Cuyahoga County Engineer John O. McWilliams.

The structure is now approximately 70 per cent completed. Only 3 spans remain to be erected and workmen have already begun arc welding (see illustration), the new type floor grating which will form a network of steel to receive the concrete pavement.

The Main Avenue bridge represents the largest use of the new arc-welding process of bridge construction ever applied to any Cuyahoga County project. The bridge involves over 60 miles of arc-welded seams, including both shop fabrication and field connection of the steel work.

Photo Courtesy The Lincoln Electric Company, Cleveland, Ohio

Modern "Steel Carpenters"—Arc-Welding Operators of the Great Lakes Welding and Boiler Company, Cleveland—"Nail" in the Flooring for Cleveland's New Main Avenue Bridge Which Is to Open June 30th.

Two 120-foot spans, which are in reality two bridges, one for the north and one for the south ramp, tying the bridge proper to the westerly approach, are of all arc-welded construction. They contain approximately 30 miles of arc-welded seams.

Of the other 30 miles of welding on the bridge, 14½ miles are in the floor grating which is laid in panels and arc welded together; 10 miles in the steel railings, all of which were fabricated by arc welding; 4½ miles in the steel curbings; and 1 mile in the modern lighting standards. Gutter drains, to carry water off the bridge, are also arc welded.

See the

NEW YORK WORLD'S FAIR

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(Auspices New York Section)

Monday, May 29, 1939

HERE is your opportunity to enjoy the Fair on a day that has been officially designated—for you—as American Welding Society Day. This gala occasion comes in the midst of the holiday weekend leading up to Decoration Day. Featured in the plans to help you see the best of the Fair in the company of your friends and associates in the Society are:

PARTICIPATION in the advantages of the Day is open to all A.W.S. members, their ladies and guests.

It will pay you and help us if you will mail your reservations promptly to Charles Kandel, Chairman, 2727 Jackson Avenue, Long Island City, New York.

Lunch only $1.00 Dinner only $2.50

Tours, Lunch and Dinner $3.25

(General Admission to the Fair, 75c, *payable at the gate.*)

Reunion at A.W.S. Headquarters in the Hall of Special Events on Fair Grounds.

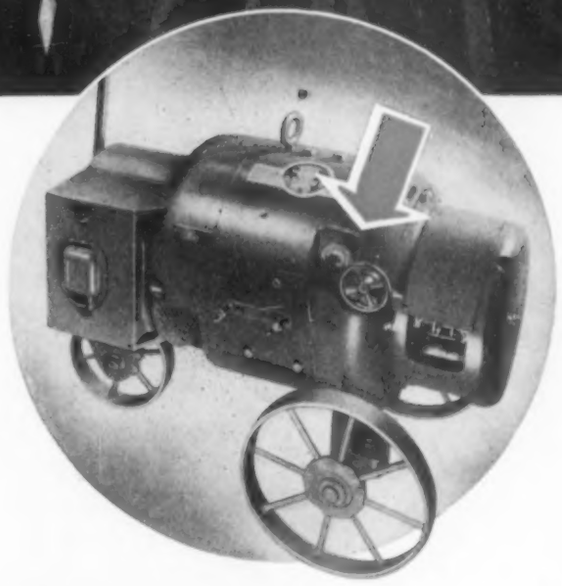
Luncheon This will be held at the picturesque Schaefer Center, one of the sights of the Fair.

Tours Uniformed guides will conduct parties hourly beginning at 10 a.m. Practically all of the exhibits except those in the amusement area will be free

Dinner Also at Schaefer Center, this Grand Reunion Dinner will be featured by *no speeches*—only delicious food and delightful music—and you will have time to get back to the glories of the Fair-by-night.

MAKE ANY TEST YOU LIKE! THE ANSWER IS THE FLEXARC WITH JUST ONE PRE-SET CONTROL

GIVE IT THE "ALL-POSITION" TEST—



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Westinghouse Flexarc Welders

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HUGE ELECTRIC TRAVELING CRANE

The Shaw-Box Crane & Hoist Division of Manning, Maxwell & Moore have just completed and shipped an exceptionally large overhead electric traveling crane to the Tennessee Valley Authority for use in the Chickamauga Power House located at the Chickamauga Dam near Chattanooga, Tenn.

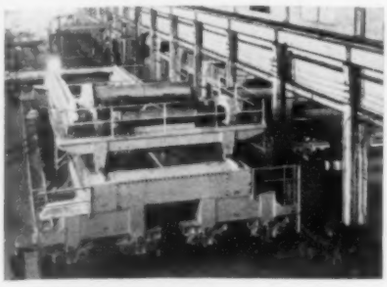

Fig. 1

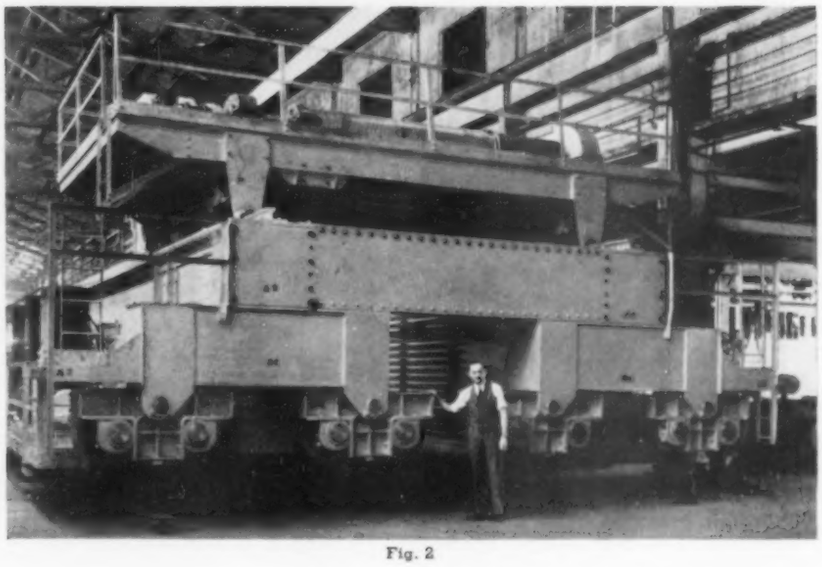

Fig. 2

It is for use to lift the turbines in this new plant into place and handle them later when servicing them. The crane has a total lifting capacity of 275 tons and is guaranteed to lift a test load of 343 tons. It is 70 feet $1^1/_2$ inch span, equipped with two trolleys each having a main hoist of $137^1/_2$ tons rated capacity, and an auxiliary hoist of 25 tons lifting capacity.

With this crane capacity loads can be raised or lowered at a speed of four feet a minute, traversed at a speed of 25 feet a minute by the trolleys and at a speed of 100 feet a minute on the bridge.

The crane complete weighs 242 tons. The over-all length is 72 feet $7^1/_2$ inches. The over-all width is 30 feet 6 inches, and it is 17 feet $^3/_4$ inch high from the bottom of the girder to the highest point of the crane.

Some of the component units entering into the construction of this crane were larger than normally encountered in crane building. The girders without any machinery, walk ways or wiring material on them weigh 41 tons each. The hoisting trolleys without the ropes or lower blocks weigh 45 tons each. The winding drums for the main hoist weigh 12 tons each. The lower blocks for the main hoist weigh four tons each.

In fabricating this crane, with the exception of a portion of the girders, the load girt of the trolleys and the end ties across the end of the bridge, all parts were welded. All gears and sheaves were also of welded construction.

As may be seen from Figs. 1 and 2, because of the heavy weights involved, the total weight of the crane and its load (543 tons) were supported on 16 wheels, eight on each end of the crane. Wheels were mounted in pairs in what are termed "equalizing trucks."

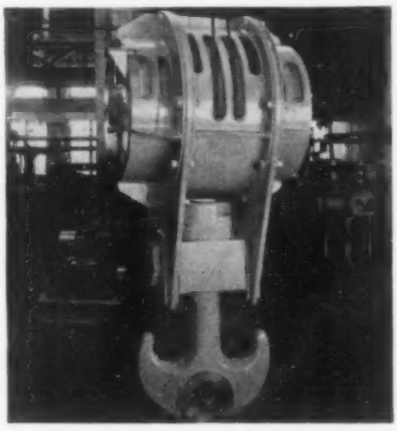

Fig. 3

Figure 3 shows one of the main hoist lower blocks and hooks, of which there are two, that are used in connection with this crane. Of particular interest is the fact that the cross heads and nuts were flame cut from high carbon steel slabs and the sheaves, which are 45 inches in diameter grooved for $1^1/_4$-inch wire rope, were produced by welding.

WELDING EQUIPMENT CATALOG

Victor Equipment Company, with headquarters at 844–50 Folsom Street, San Francisco, is now ready to release, through its national distributing organization, a new and comprehensively illustrated 32-page welding and cutting apparatus catalog.

Of particular interest to the reader are the numerous welding and cutting units. The catalog has been carefully designed to simplify the purchase of VICTOR equipments, and it offers all essential facts necessary to guide the purchaser in a suitable selection from the very large variety of torches, regulators and accessories manufactured by this internationally known producer of welding apparatus.

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COVETED HONOR TO STEEL MAN

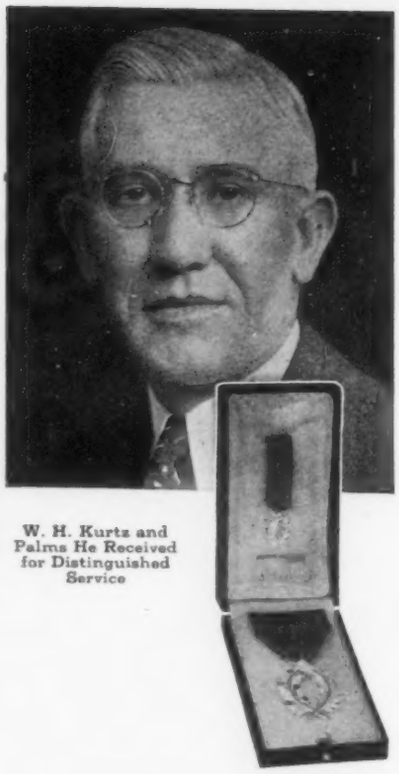
Mr. Walter H. Kurtz and the Palms of the French Academy He Received for Distinguished Service

One of the highest honors a man of science, arts or literature can receive from the French government is the Palms d'Officier d'Academie.

Walter H. Kurtz, general superintendent of maintenance of the Sheffield Steel Corporation, was recently presented with this distinguished honor and with the medals shown above by Dr. Hans Schaerrer, Consular Agent of Switzerland and Dr. Wm. Schaerrer, French Counsel of Kansas City. The honorary degree was dated November first, 1938, in Paris, France.

The membership in the French Academy is limited. Candidates are first elected and then approved by the Minister of National Education of France and by the Chief of the Bureau of the Cabinet. To qualify: a candidate must have done some noteworthy, original and responsible work in France, must be a graduate of a University of high order and have a master or professional degree. He must also be the author of articles, papers or books which are considered an important contribution to his profession.

Mr. Kurtz served in the World War as a special technical engineer under General W. W. Atterbury, the late president of the Pennsylvania Railroad. He served with the General Superintendent of Motive Power, the Engineer of Construction, and



W. H. Kurtz and Palms He Received for Distinguished Service

with various engineering regiments of the United States Army, and was on detached service with the French and Belgian engineers on locomotive construction and railway facilities.

Mr. Kurtz is a graduate of the Washington University in St. Louis, Missouri, and received the degree of Bachelor of Science in Mechanical Engineering June 1917, and the Professional degree, Mechanical Engineer in June 1923.

In addition to being elected an officer of the French Academy Mr. Kurtz has been decorated by various European countries for distinguished service during the World War.

UNITED STATES CIVIL SERVICE EXAMINATIONS

Naval Architect, $3800 a year
Associate Naval Architect, $3200 a year
Assistant Naval Architect, $2600 a year

Optional Branches: 1. Ship piping and ventilation. 2. Hull structures and arrangements. 3. Scientific ship calculations. 4. General. 5. Small boats. Applications will be rated as received until December 31, 1939.

Duties.—Under general or direct supervision, according to the type of the position, to prepare contract and type plans or hull construction plans for new designs of vessels or for vessels under construction, alteration or repair; to conduct theoretical investigations; to make studies and calculations in connection with ship

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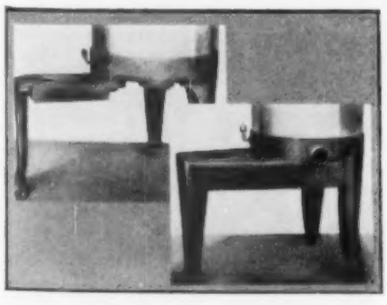

• A FAIR example is this stand, typical of bases and frames used on many machines. On the left we have the former construction—a collection of parts bolted together. On the right we have the design of today—a rigid unit of welded pressed steel, streamlined for eye appeal and sales.

Cost has been cut from $28.70 to $12.64—a saving of $16.06. Breakage troubles have been eliminated. And the new model can be supplied in any desired height without extra cost for patterns or delay. This is just one example of how this manufacturer improved gate receipts by giving welding a FAIR chance to gain *headway* in the plant.

What's the key to this *headway? Appoint a HEAD-MAN*—a Profit

Crusader with a flair for driving costs down and quality up with welding. When you're courting Miss Progress 1939, the old saying still goes, "Faint heart ne'er won FAIR lady." Let Lincoln give you some pointers on successful approach.

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DEPT. DD-597 **CLEVELAND, OHIO**

hull design and construction; to check and criticize plans, calculations and estimates; and to prepare technical correspondence. The difficulty and responsibility of the work will vary with the grade of the position.

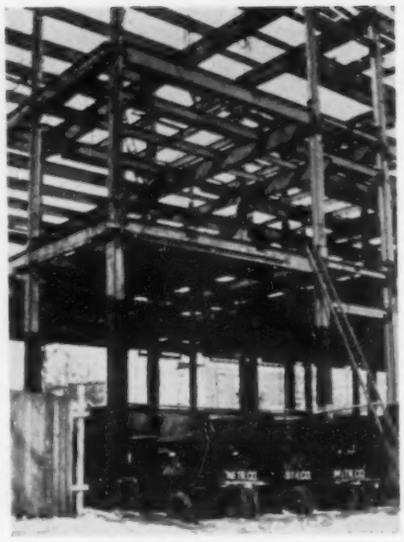
Marine Engineer, $3800 a year
Associate Marine Engineer, $3200 a year
Assistant Marine Engineer, $2600 a year

United States Maritime Commission and Navy Department applications will be rated as received until December 31, 1939.

Duties.—To prepare installation plans, layouts and specifications for marine machinery such as marine boilers, engines, turbines, Diesel engines, auxiliaries, power plant piping, deck machinery and electrical power machinery; to make studies and calculations in connection with the design or selection of such machinery; to investigate and analyze designs and proposals submitted by contractors; to conduct trials and tests of marine machinery; to prepare technical correspondence; and to perform other duties in the field of professional marine engineering as assigned. The difficulty and responsibility of the work will vary with the grade of the position.

WELDED FOUR-STORY SCHOOL BUILDING ERECTED IN TWO WEEKS

Public School No. 213, located at Hegeman Avenue, Brooklyn, N. Y., is the latest addition to the growing list of arc-welded buildings in the metropolitan area of New York City. This is a four-story building, 182 feet 7 inches long. The width is variable, since it has an east wing 89 feet 11 inches by 60 feet, and a west wing 61 feet 5 inches by 60 feet. The building was erected and welded within two weeks after placing the first column. Five 300-ampere welding generators were used, and all welding was done with shielded-arc electrodes. Current control was facilitated by installing all five of the welding machines at one corner of the building, where they remained until the welding was completed, with an engineer-in-charge. Welding operators were able to signal for any necessary adjustments and the close grouping of the machines permitted one man to take care of all of them without loss of time. Approximately 420 tons of steel were used in the construction.



A. S. T. M. ANNUAL MEETING

Fifth Exhibit of Testing Apparatus and Related Equipment June 26th to June 30th, Atlantic City, N. J.

Upward of twenty separate technical sessions will be necessary at the 1939 A. S. T. M. Annual Meeting of the American Society for Testing Materials to be held at Chalfonte-Haddon Hall, Atlantic City, N. J., to provide for the presentation of the large number of technical papers and reports. Quite a number of the sessions will be in the nature of round-table discussions and others will feature symposiums comprising several papers on a particular subject. Throughout the week of the meeting, there will be in progress the Fifth Exhibit of Testing Aparatus and Related Equipment, and also the Society's Photographic Display, which this year will be devoted to the theme "Testing and Research in Engineering Materials."

Among the important technical features are Discussions on Paint Testing, Shear Testing of Soils, Quantitative Spectrochemical Analysis, Effect of Subatmospheric Temperatures on the Properties of Metals, and Freezing and Thawing. There will be groups of papers also covering water, fatigue of metals, asphalt, radiography, and concrete and concrete aggregates.

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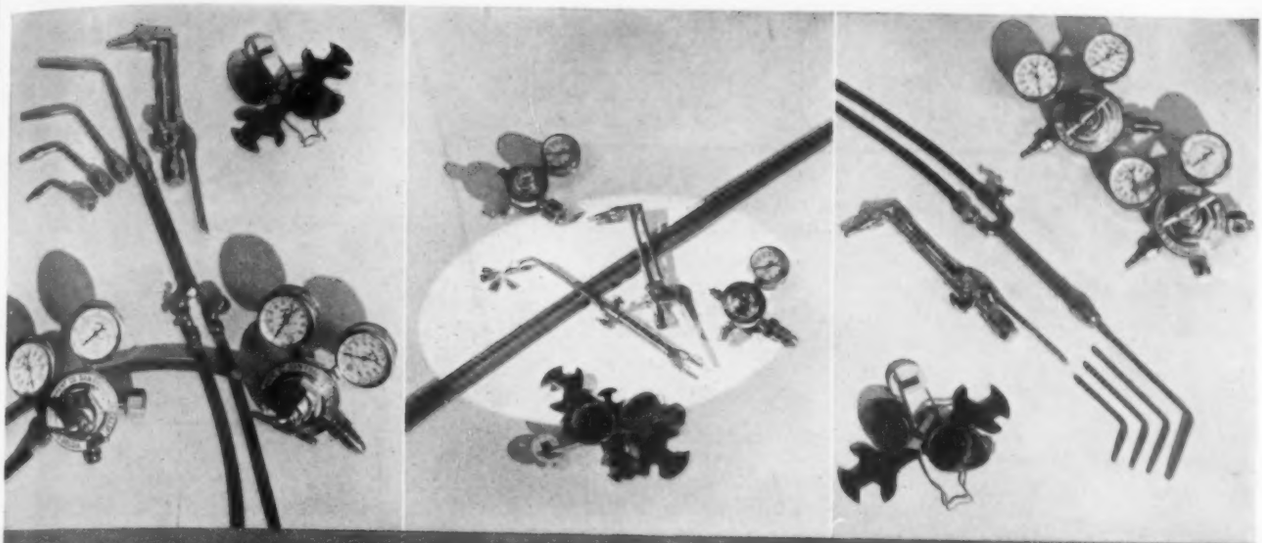

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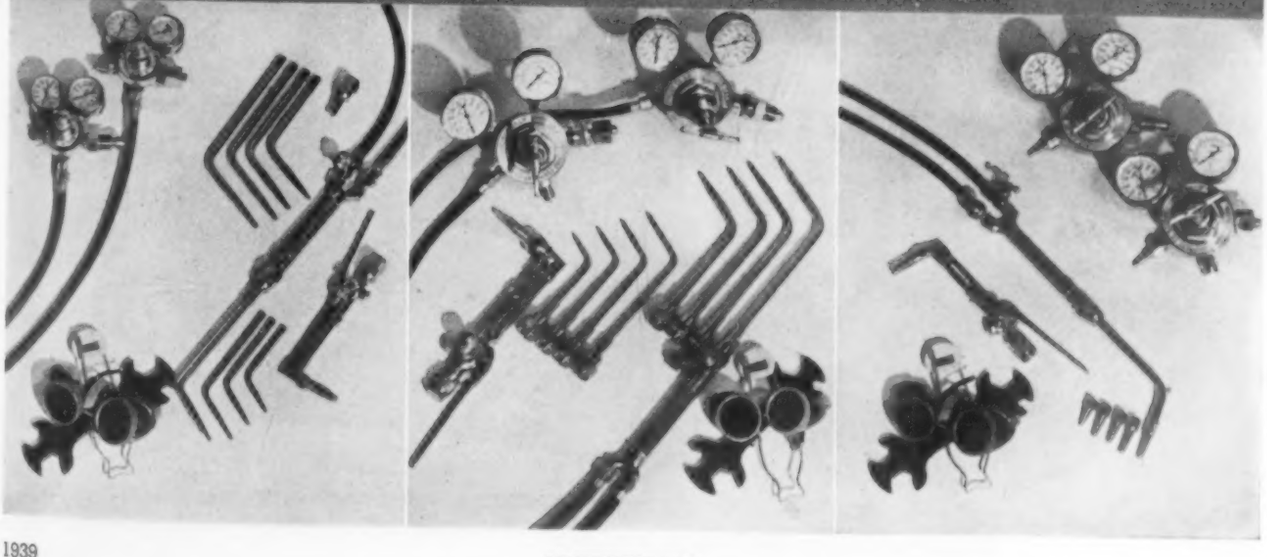
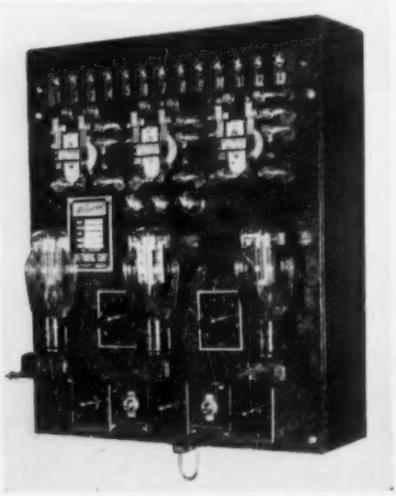


NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

WELDING TIMERS

Following a year of successful operation of experimental installations in regular production on varying types of welding installations in a number of different plants Weltronic Corporation, Detroit, announces the commercial availability of its line of electronic welding timers.



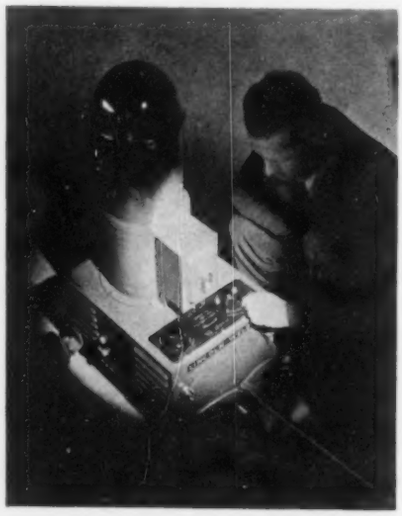
Designed for use with gun, spot, projection and automatic welding equipment, the line comprises models ranging in application from single spots to multiple automatic spot welding. Up to six hundred spot welds per minute in regular production have been made with these new timers.

Simplicity and positiveness in operation are effected in the new Weltronic timers through the use of electronic tubes, reducing the number of moving parts to such an extent that but a single relay and a single tube are now required for full automatic control of a gun, spot or automatic welding machine. Their use permits the selection of virtually any combination of welding factors desired.

SMALL ARC WELDER

A small motor-generator type arc welder, said to provide greater convenience and accuracy in welding because of a new self-indicating dual continuous current control, is announced by The Lincoln Electric Company, Cleveland, Ohio.

Because of its advanced features and moderate price, this unit is expected to widen the application of welding in new fields such as garages, bus and truck fleet repair shops, sheet metal shops, maintenance departments of pulp and paper mills, paint mills, cement plants, textile plants, gas plants, and similar plants in the process industry, as well as metal fabricating shops, piping work etc.



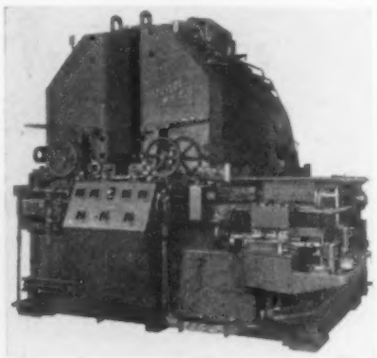
DUPLEX WELDING HOSE

Condor Duplex Welding Hose, a development of The Manhattan Rubber Mfg. Division, Passaic, N. J., is a highly practical twin hose designed to make welding safer and more efficient than is possible with separate oxygen and acetylene lines.

In the construction of Condor Duplex, two hose lines are held together by a permanent web joint, integrally molded and having great strength and flexibility. The joint prevents tangling, kinking and snagging while the hose is in use. The ends are separated 18 inches for the torch end and 24 inches for the tank end for ease in making connections and in handling.

SYMPOSIUM OF THE WELDING OF STRIP STEEL

In connection with the latest design of The Taylor Winfield full automatic hydraulic strip mill welder with Morton



hydraulic flash trimmer, a demonstration and symposium was held on the 21st of March at Warren, Ohio.

One of the important features incorporated in these machines is the accessibility of controls, their being located within easy reach of the operator. All operating adjustments are made by means of levers and dials all fully calibrated eliminating all "cut and try" settings.

Another important new feature of these machines is the provision for elevating the entire clamping fixture without dis-

And Now, a Modern
ELECTRODE
McKAY
SHIELDED
ARC WELDING
Electrodes
The right electrode and the right method for each job are the keys to successful welding. Every modern resource is employed to improve McKay Electrodes and to aid the user. Ask for folder.
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McKay Building
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WELDING AND CUTTING EQUIPMENT
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Send for Catalog R-120 — with it you will have all the specifications you need for the buying of highest quality welding and cutting equipment.
The BASTIAN-BLESSING Company
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★ BARE WELDING ELECTRODES

★ COVERED WELDING ELECTRODES

★ GAS WELDING WIRE

ROEBLING WELDING CABLES:

Made in a complete line of rubber and braided types for arc welding purposes.

JOHN A. ROEBLING'S SONS COMPANY, TRENTON, N.J.
Branches in Principal Cities

ONLY A FINE PRODUCT MAY BEAR THE NAME ROEBLING

turbing any air, electrical or hydraulic connections. The elevation of these clamping fixtures permits full inspection, maintenance and removal of the welding dies.

The machines have a maximum stock width of 38 inches. The control boards are mounted on the machines which control other equipment in the line, as well as the welder itself.

Following the demonstration of the machines in the morning, lunch was served in the factory.

Several engineers from the Taylor Winfield took part in this symposium, which covered such steps as: Introduction, Factors Entering Machine Design, Factors Entering Electrical Design and Control, Strip Handling, Factors Entering Design and Operation of Flash Trimmers, Improved Features of Operation, General Discussion of Operating Problems.

A number of prominent operating and engineering executives were present.

PORTABLE X-RAY MACHINE

The latest weapon in the inevitably victorious campaign against flaws in industrial products, a 220-kv. portable X-ray flaw detector, recently was placed in service in examining structural welds and heavy castings on production lines at the East Pittsburgh works of the Westinghouse Electric & Manufacturing Company.

The Flexible Tube and Focusing Device of This 220,000-Volt Portable X-ray Machine Enable the Apparatus to Be Aimed at Welds in Any Position in Massive Steel Equipment Being Diagnosed for Possible Defects

The technique of radiographic diagnosis of large steel parts is expected to be much simplified by this 4500-pound portable X-ray camera, since it may be wheeled along production lines to maintain the quality of machines during their manufacture.

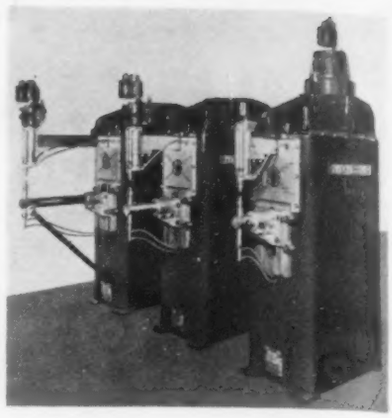
Shockproof, completely self-contained, ready for work wherever there is a proper power supply, it generates X-rays with a penetrating quality sufficient for them to pass through three inches of solid steel. The focusing mechanism on the new equipment is extremely flexible, so that the apparatus may be aimed at a weld or casting in either a horizontal or vertical position.

X-ray tube, transformer, capacitors and flexible focusing device are all compactly mounted on a chassis with four balloon tires, automobile springs and two-wheel mechanical brakes, enabling two men to move the apparatus in safety.

SPOT WELDER

A "Multi-Duty" Spot Welder built around an entirely new design of welding head employing a sliding contact has been announced by Progressive Welder Company, Detroit. The design, which has been subjected to all types of field tests during the past year, permits in the spot welder the elimination of flexible connections in favor of solid arms, the interchangeable use of air-hydraulic or pneumatic boosters for pressure application, a material reduction in current consumption, a vastly widened range of uses due to the more accurate pressure control, use of guns individually or in multiple—mounted vertically, horizontally or at angles, interchangeable use of 75 to 150 kva. and larger transformers, etc.

These features of the new welder are due mainly to the manner of applying both welding pressure and current through a cable—less welding head—directly to the welding point. Unrestricted current transmission directly through the gun is made possible by an off-center mounting of the welding point which,



under full welding pressure, causes a "cocking" action and forces the gun piston tightly against its cylinder. Experience has shown that scoring of either piston or cylinder even at maximum production speeds or with heavy-duty work has been effectively eliminated by the types of metals and lubrication method used.

BRONZE WELDING ROD

Of extraordinary importance to the welding trade is the announcement just released by the Compressed Industrial Gases, Inc., Chicago, Illinois of their two new bronze-welding rods. These rods are known as CIG No. 400 "Ready-Fluxed Bronze Rods and CIG No. 401 "Ready Fluxed" Manganese Bronze Rods. As their name implies, they are completely flux-coated throughout their entire length all ready for the oxyacetylene welder to apply in his welding jobs.

It controls the even introduction of the chemically correct flux throughout the entire brazing operation. It prevents the weld from getting too much or too little bronze and completely shields the molten metal from the time the weld area is first tinned until the job is completed.

With CIG Ready-Fluxed Bronzes the brazing operation will be a continuous process and in exhaustive tests it has been estimated that a 15% saving in operators' time and 15% in gas consumption.

The CIG No. 401 Ready-Fluxed Manganese Bronze Rods are particularly desirable for bronze welding of cast iron.

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them

The Trade-Name is "ANTI-BORAX"

Ask For Them ***Unequaled for Quality***

A Flux for every metal: Cast Iron Welding Flux No. 1.; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; "Anti-Borax" Tinning Compound No. 11.

Send for Free Samples

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Fort Wayne, Indiana

SAVE MONEY. . . BY WELDING

Jaw Plates, Gyratory and Roll Crushers, Shovel Teeth, Hammers, Tractor Tread Grousers
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11 to 13½% Nickel Manganese Steel

WELDING ELECTRODES, WEDGE and APPLICATOR BARS, HOT ROLLED PLATES

STULZ-SICKLES CO. *Sole Producers* 134-142 Lafayette St., Newark, N. J.

Sold Thru Distributors Only

The leading manufacturers of Resistance Welding Equipment announce the formation of the

RESISTANCE WELDER MANUFACTURERS ASSOCIATION

the principal purpose of which is to further the art of resistance welding. The member companies will endeavor to promote the simplification of types of equipment and broaden the understanding concerning welding applications.

Further announcements will be made in these pages from time to time.

Resistance Welder Manufacturers Association

MEMBER COMPANIES

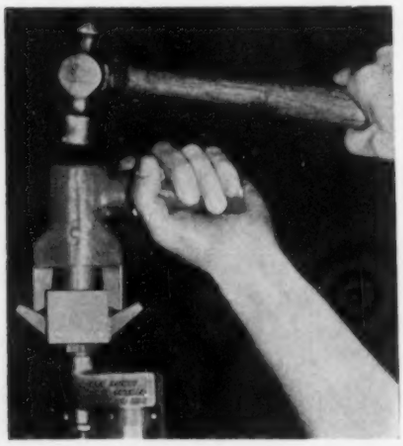
Acme Electric Welding Company, Los Angeles
American Electric Fusion Corporation, Chicago
Eisler Engineering Company, Newark, N. J.
Expert Welding Machine Company, Detroit
Federal Machine and Welder Company, Warren
National Electric Welding Machines Co., Bay City
Progressive Welder Company, Detroit
Swift Electric Welder Company, Detroit
Taylor-Hall Welding Corporation, Worcester
Taylor-Winfield Corporation, Warren
Thomson-Gibb Electric Welding Co., Lynn
Welding Machines Mfg. Company, Detroit

ASSOCIATE MEMBER COMPANIES

P. R. Mallory and Co., Indianapolis
S-M-S Corporation, Detroit
Electroloy, Inc., New York
Welding Sales and Engineering Co., Detroit

WELDING POINT-PULLER

A simple taper point-puller for hydromatic and multiple spot welders is now being offered by Progressive Welder Company, Detroit. Features of the puller are: automatic locking—no slipping or scoring of the electrode; positive grip; instantaneous operation; straight-line pulling action; and light weight.



The design of the puller is such as to eliminate damaging of the welding point seats. The puller jaws are slipped over the electrode, a slight lift of the handle seats the jaws and a tap of a hammer on the bottom of the puller removes the electrode from the holder.

NEW ELECTRODE

A new arc welding electrode for use with alternating current transformer type welders which have low open circuit voltage is announced by The Lincoln Electric Company, Cleveland, Ohio.

The new electrode, known as "Readyweld," is a low-carbon steel rod with a heavy extruded shielded arc coating possessing properties which assure arc stability and easy re-striking of the arc with small low-voltage transformer welders.

"Readyweld" is intended for general welding and repair work on light gage sheet steel. The electrode provides weld metal which possesses high strength and ductility. Because of its desirable arc characteristics, the electrode permits easier and better welding in the type of work for which it has been developed.

SMALL FLEXARC A-C WELDERS

The Midget Marvel Flexarc a-c welder, comprising a special transformer and control for a-c arc welding and meeting the demand for an economical low-priced welder for all-around maintenance and shop work, as well as light construction work, is described in a new leaflet released by the Westinghouse Electric & Manufacturing Company.

REDUCTION OF VALVE GEAR WEAR

The article, "Wear Reduction of Valves and Valve Gear," by A. T. Colwell of Thompson Products, Inc., which appeared in the September, 1938, issue of *S. A. E. Journal*, has just been reprinted by Haynes Stellite Company, Unit of Union Carbide and Carbon Corporation. This article is a thorough discussion of automotive and aircraft engine valve wear. It presents a number of methods of overcoming valve gear wear and many recommendations for materials which have proved themselves successful after conclusive service tests. Copies of the reprint are available from Haynes Stellite Company, Kokomo, Indiana.

» » » SECTION ACTIVITIES « « «

BIRMINGHAM

At the March meeting held on the 2nd, Mr. A. N. Kugler of the Applied Engineering Department of Air Reduction Sales Company, New York, presented an illustrated talk with colored motion picture film and slides, on "Structural Steel Welding in New York City." The first all-welded steel building in New York City, and how it was built, was described by Mr. Kugler. The attendance at this meeting was 150, and Mr. Kugler's talk was very well received.

BOSTON

The regular monthly meeting of the Boston Section was held on April 17th. Mr. J. M. Keir, of The Linde Air Products Company, discussed the "Unionmelt" welding process recently developed by The Linde Air Products Company. Three reels of film were used to supplement Mr. Keir's talk on the subject.

CHATTANOOGA

The Chattanooga Section of the AMERICAN WELDING SOCIETY held their regular meeting Tuesday evening, April 4th, in Hotel Patten.

Principal speaker was Mr. E. R. Seabloom, Research Engineer, Crane Company, Chicago. The subject of his talk was "The Application of Fusion Welding to Pressure Piping," with particular emphasis on Code requirements for pipe welding, qualification of welding operators, procedure controls and surface depositing of valve seats.

CLEVELAND

The Cleveland Section is happy to report a very fine attendance at their spring series of educational lectures held at Bingham Hall, Case School of Applied Science, by Mr. C. C. Peck, President, Contract Welders, Inc., on "Stretching the Welding Dollar" or "How Some Welding Problems Were Solved." These lectures were held on March 10th, 17th, 24th and 31st.

Dr. J. C. Hodge of Babcock & Wilcox Company, talked to a large and very attentive crowd on April 12th at Cleveland Club on "Metallurgical Factors Which Determine Weldability."

Mr. Grover Hughes' talk originally scheduled for April 12th was postponed until May 10th.

COLUMBUS

At the regular meeting, held April 14th at Hotel Fort Hayes, the guest speaker of the Section was Mr. Everett Chapman, President of Lukenweld, Inc., who spoke on "Stress Distribution in Welded Joints." The meeting was preceded by a dinner, which was well attended by members and visitors from the various industries in and around Columbus.

The next regular meeting will be held May 11th in conjunction with the 6th Annual Welding Conference to be held at Ohio State University. The meeting will be held at Hotel Fort Hayes, preceded by a dinner meeting and the guest speaker will be Mr. Radcliff from The Linde Air Products Company. Mr. Radcliff will speak on the subject Unionmelt.

New officers of the Section were elected at the last meeting. They are:

Chairman—F. C. Caldwell, Jeffrey Mfg. Co.

Vice Chairman—J. A. Foust, Prof., Ohio State University

Secretary-Treasurer—George S. Herron, The Seagrave Corp. (Re-elected)

Three new members on the Executive Committee to serve for 2 years: P. O. Storts, F. B. Dakle and Clay Roberts.

KANSAS CITY

The following officers were elected March 15th for the fiscal year.

Chairman—James L. Frizzell, National Steel Products Co.

Vice-Chairman—Ned Ashton, Ash, Howard, Needles & Tammen

Treasurer—Chas. E. Donegan, The Linde Air Products Co.

Secretary—Jim Kirk, Air Reduction Sales Company.

This badly cracked Engine Block completely repaired in 10 hours

Oxy-acetylene welding with 10 lbs. of Tobin Bronze rod saves 300 lb. casting from the junk pile

When cracks appeared in the base of this crude-oil engine block, attempts to prevent their extension by clamps proved futile. In a short time they had practically encircled the cylinder—only fifteen inches of solid metal remaining between the ends of the cracks.

In this condition the engine was of course useless. A replacement meant a large investment and an important time loss waiting for the new casting. It was then that Tobin Bronze welding was suggested. And just ten hours after that suggestion was made, the engine base was ready to go back into service.

Every day, in all parts of the country, similar incidents demonstrate that expensive equipment, seemingly damaged beyond repair, can often be salvaged at nominal cost by welding with Tobin Bronze—a time-tried Anaconda product. The trade-mark "Tobin Bronze Reg. U. S. Pat. Off." is stamped in every rod. Look for it to make certain that you are getting genuine Tobin Bronze. 39130

MELTING POINTS OF ANACONDA WELDING RODS

Material	Approx. Melting Point—Degrees		Material	Approx. Melting Point—Degrees	
	Cent.	Fahr.		Cent.	Fahr.
Tobin Bronze* . .	885	1625	Phosphor Bronze E	1070	1958
Anaconda 520 . .	885	1625	Phosphor Bronze D	1000	1832
Manganese Bronze	870	1598	Phosphor Bronze C	1025	1877
Anaconda 997 (low fuming)	870	1598	Silicon Copper . .	1083	1981
Brazing Metal . .	930	1706	Deoxidized Copper	1083	1981
Economy Bronze* .	885	1625	Electrolytic Copper	1083	1981
Everdur*	1019	1866	Super Nickel . .	1225	2237
Phosphor Bronze A	1050	1922	Nickel Silver . .	1055	1931

*Trade-marks Reg. U. S. Pat. Off.

ANACONDA *Anaconda Welding Rods*

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company

TIGH
BOU

HTLY
UND

Following the election of officers, an address on "Boiler and High Pressure Vessel Welding and Codes Relating to Welding" was given by Mr. C. W. Obert of The Linde Air Products Company, New York.

The 5th Annual Welding Conference in Lawrence, Kansas, at the University of Kansas, was held on April 13th and 14th. Among the lectures given were the following:

Atomic Hydrogen Welding, by W. M. B. Brady, General Electric Co.
Research in Welding, by Prof. LaMotte Grover, Kansas State College
Unionmelt Process, by F. C. Hutchinson, The Linde Air Products Co.
Strength of Materials, by Prof. A. M. Ockerblad, University of Kansas
Machine Design and Structural Design for Arc Welded Construction, by E. W. P. Smith, The Lincoln Electric Company
Structural Steel Welding in New York City, by A. N. Kugler, Air Reduction Sales Co.
Arc Welding as an Industrial Tool, by Prof. W. W. Carlson, Kansas State College
Flame Hardening, by G. F. Dickins, Air Reduction Sales Co.
Fabrication of Monel, Nickel and Inconel; and Nickel-Clad and Inconel-Clad Steels, by F. P. Huston, International Nickel Co.
Electrodes, by R. D. Thomas, Arcos Corp.
Pipe Line Welding, by O. Mauck, Sinclair Refining Co.
Hard Surfacing, by T. B. Jefferson, Office of Chief Engineer, War Dept.

The May meeting will be held on the 15th, with Mr. C. H. Jennings of the Westinghouse Elec. & Mfg. Company as guest speaker. His subject will be "Distortion Problems in Welding."

LOS ANGELES

The regular meeting of the AMERICAN WELDING SOCIETY, Los Angeles Section, was held on Thursday Evening, February 16, 1939, on the fourth floor of the Commercial Club Bldg., 11th and Broadway, Los Angeles, California.

There were 70 members and guests present for the dinner, with about 30 additional attending the meeting following.

An interesting paper, on "Arc Welding and the 200-Inch Telescope," by Mr. Edmund G. Grant, California Institute of Technology, was read and illustrated. This paper was the one that was awarded the $2000 in the 1938 Lincoln Foundation Award. He described at length the saving in arc welding on the construction of this giant telescope.

Mr. Waldman, Western Manager of Chicago Steel and Wire Company, San Francisco, presented two films on "The Welding Arc." One of these films was in color. This picture showed in detail the action of the arc and of the metal crossing along the arc into the molten pool. Both the paper and the pictures received quite a little comment and discussion among the members.

MEMPHIS

A reorganization meeting and election of officers of the Memphis Section was held on March 31st. Mr. E. H. Gill of the National Butane Co., Memphis, was unanimously elected Chairman of this Section. Mr. B. B. Drury, Jr., was unanimously elected Secretary-Treasurer.

It was decided not to elect a Vice-Chairman, or members of the Executive Committee, until the next meeting.

MILWAUKEE

The regular monthly meeting of the Milwaukee Section was held on March 31st in the City Club of Milwaukee. Meeting was preceded by a dinner at which an after dinner talk was given by Daniel J. McNally, Manager of Public Affairs Division, Milwaukee Association of Commerce, whose address was on "Less Taxes and Less Government in Business."

Mr. Edward J. Brady, Manager, Stainless and Alloy Electrode Division, The McKay Company, presented an address on "Arc Welding the Stainless Steels."

MONTANA

The Montana Section held their annual election of officers at their regular meeting Thursday, April 6th. The officers elected are as follows:

Chairman—Wm. Galloway
Vice-Chairman—W. P. Gray
Secretary-Treasurer—Harry S. Griffith
Executive Committee—Chester W. Capper, Peter J. Carpani

After all the other business of the Section was taken care of, the entertainment for the evening was five reels of motion pictures. Two reels were on "All Welded Steel Buildings" and three reels on "Welded Structures Are Cheaper and Stronger Than Castings." These pictures were obtained from Mr. John D. Fradet, a member of the Section and The Lincoln Electric Company. The pictures were much enjoyed by all present and all took part in an open discussion which followed.

The next regular meeting of the Section will be held May 4th in Fort Peck, Montana.

NEW YORK

A Joint Dinner and Technical Meeting of the AMERICAN WELDING SOCIETY, N. Y. Section and American Society for Metals, New York Chapter, was held at the Building Trades Club, 2 Park Avenue, N. Y. C. on Monday, April 10, 1939. Dinner was served at 6:15 P.M. with about 80 persons on hand. The Technical Sessions started at 8:00 P.M. before a group of about 185. An excellent paper entitled "Low-Alloy Structural Steels" was presented by Mr. A. F. Stuebing, Sales Engineer, Carnegie-Illinois Steel Corporation, Pittsburgh, Pa. Mr. Stuebing's talk covered composition and properties of the recently developed classes of low-alloy structural steels, their field of application and factors to be considered in their utilization, including designing, fabricating and welding. The lecture was accompanied by a number of interesting lantern slides. There was a lively discussion following the paper. Afterward, Mr. Stuebing showed an outstanding sound film on U.S.S. Cor-Ten Steel. The Technical Chairman of the Meeting was Mr. J. H. Critchett, Vice-President, Electro Metallurgical Corporation and Union Carbide & Carbon Research Laboratories.

NORTHWEST

A. M. Unger, of the Pullman Standard Car Manufacturing Company, spoke on the subject of "Welded Railway Car Construction," which was illustrated by sound movies and slides, at a meeting of the Northwest Section, held Wednesday, April 19th. Mr. Unger covered in his talk the most recent developments in the practice and application of welding heavy steel plates.

OKLAHOMA

The April meeting of the Oklahoma City Section was preceded by a dinner meeting and following the dinner the program was in charge of and presented by the student members of the AMERICAN WELDING SOCIETY attending the School of Technical Training at Oklahoma Agriculture and Mechanical College, Stillwater, Oklahoma, and in this respect the program proved different from anything ever presented before the Section.

The welding school of the department of technical training is under the supervision of William H. Rice, who acted as Master of Ceremonies and introduced the various speakers, his students.

The boys furnished some entertainment for the program in presenting a juggler of their own number. He was introduced as Professor Ino Dropem, and as giving "a demonstration in ballistics."

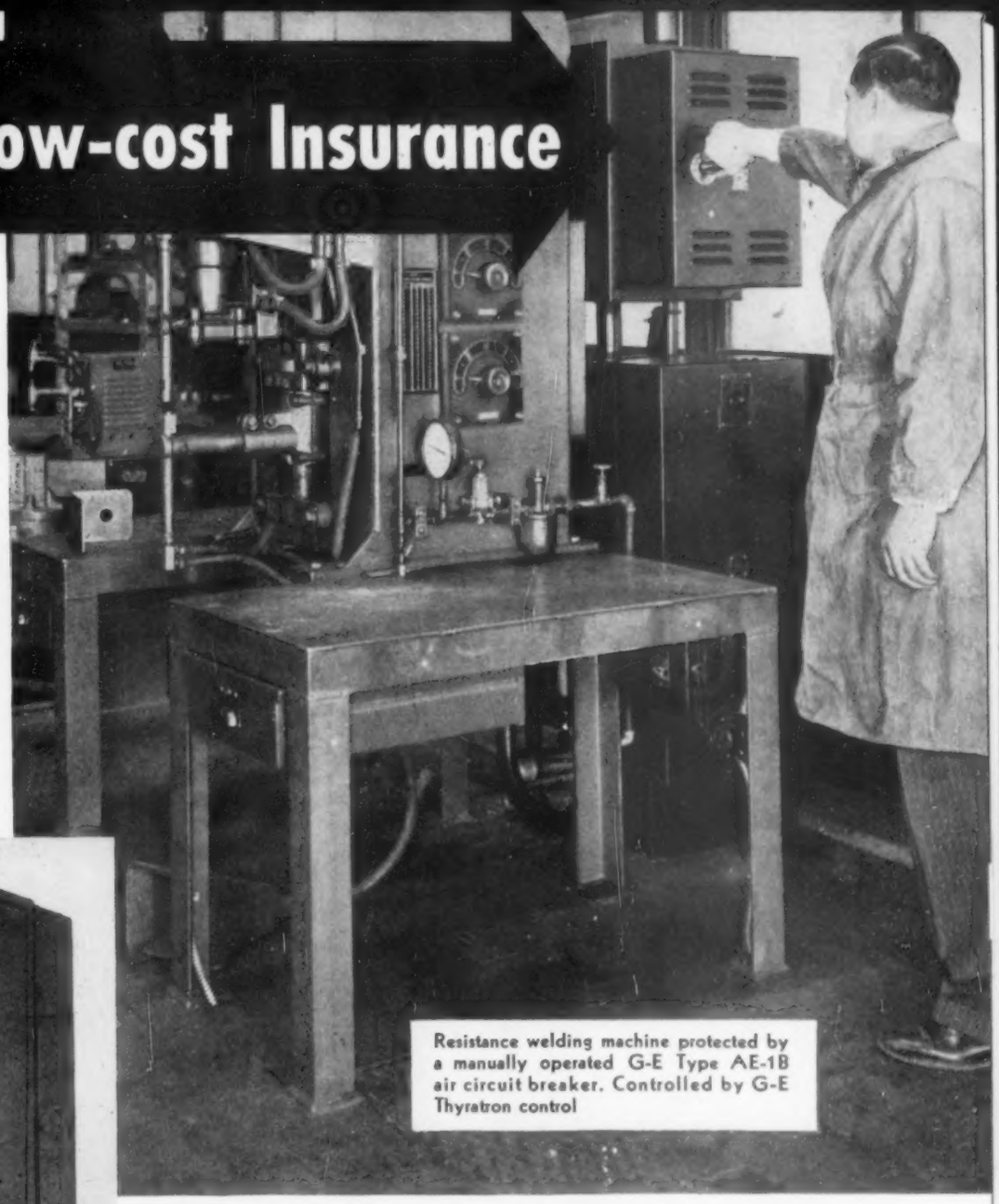
The boys presented papers covering various phases of their welding activities. One of the papers presented outlined the course of study in the school of technical training. Another covered maintenance welding as observed by one of the boys during his period of employment with one of the large lumber companies in the Southwest.

A paper relative to the characteristics of the welding generator was presented also by one of the students, and another student presented a paper relative to the development of steam by means of a "sun-boiler." His paper was based on information and observation gathered through his experimental work with this equipment on the campus.

Some humor was added to the program by the presentation of a paper dealing with the possibilities of the welding of wood and its various salvage applications. This paper was prepared by Professor Eisenkoph; however, owing to the inability of the professor to attend, the paper was presented by William H. Rice. At the conclusion of the paper, the professor, himself, appeared very hastily followed by an irate victim of the professor's suave manner and impressive language and the professor was proved to be an impostor.

's Mighty Low-cost Insurance

Protect Your Resistance-welding Machines with G-E Air Circuit Breakers



Resistance welding machine protected by a manually operated G-E Type AE-1B air circuit breaker. Controlled by G-E Thyratron control

Manually operated AE-1 air circuit breakers are reclosed by merely flipping the operating handle—no parts to replace

FOR a small fraction of the cost of your welding machine you get continuous, high-speed production, and protection for the machine and its operator. That's something worth thinking about.

When a G-E air breaker trips out, you need only push a button or flip a handle to restore service. But the real advantage is that it will trip out only when it should do so.

That's because G-E breakers are equipped with adjustable instantaneous overcurrent trips which can easily be set from the lowest to the highest current values of the breaker. The magnetic trips come into action only when the current exceeds the predetermined setting.

Should a short circuit occur, the breaker opens instantly, and the famous G-E "arc quencher" snuffs out the arc before your watch can tick twice.

These are only a few of the reasons why welding engineers all over the country are more and more using G-E Type AE-1 air circuit breakers. Ask your G-E representative for information about these breakers, or write General Electric, Schenectady, N. Y.

SEE THE G-E "HOUSE OF MAGIC" AT BOTH FAIRS

GENERAL ELECTRIC

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PEORIA

The regular April meeting was held on Wednesday, the fifth. The preliminary opening of the meeting included the showing of the Bethlehem Steel Company's sound film "The Manufacture of Structural Steel Shapes and Related Products." The main feature of the evening was a lecture delivered by Mr. Otto C. Voss, General Advisory Superintendent of the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, on the subject "The Flame Cutting and Welding of Wrought Steel and Shapes." About seventy members and guests were present, and their enthusiastic response to both the film and lecture indicated that it was one of the best meetings of the year.

A paper was presented before the Peoria Section of the American Society of Engineers on March 21st by Mr. Walter J. Brooking, from the Engineering Department of R. G. LeTourneau, Inc., on the subject "The Control of the Arc Welding Process from the Engineering Department."

PHILADELPHIA

A joint meeting of the Philadelphia Section, AMERICAN WELDING SOCIETY and Metropolitan Philadelphia Chapter, American Foundrymen's Association, was held on April 17th. Dr. C. W. Briggs, Technical Adviser, Steel Founders Society was the guest speaker. His subject was on "Welding of Steel Castings and Welded Structures." At the dinner which preceded the meeting, a coffee talk was given by Mr. A. B. Leckie, Special Agent in Charge of Federal Bureau of Investigation, whose subject was on "Crime and the Businessman."

An Annual Inspection Trip to the Philadelphia Navy Yard, League Island, Philadelphia, will be held on Wednesday, May 17th at 1:30 P.M.

ROCHESTER

The April meeting of the Rochester Section was held on the 6th. Dinner preceded the meeting, at which a coffee talk was given by Mr. Chas. Carey of Eastman Kodak Co., who spoke on "Oil Field Welding in South America."

Mr. J. M. Keir of The Linde Air Products Company, the guest speaker at the meeting, spoke on "The Union Melt Process."

ST. LOUIS

Mr. N. A. Schmidt, Engineering Department, Modern Engineering Co., addressed the April 14th meeting of the St. Louis Section on, "Safety in Modern Welding Apparatus Design." Mr. Schmidt's talk was illustrated and was of interest to all.

SAN FRANCISCO

The regular monthly meeting of the San Francisco Section was held on Friday, March 24th, at the Athens Athletic Club. Chairman Ward announced members of the Nominating Committee appointed to determine the regular nominees for office for the coming year.

Following this a report was made by Mr. E. L. Mathy, Chairman of the World's Fair Welding Day Committee. Mr. Mathy announced that the make-up of the committee had been completed and that the first general meeting of this committee would be held on April 11th.

Mr. C. S. Smith, District Manager for The Linde Air Products Company, gave an interesting talk illustrated with slides on Stack Cutting.

A joint meeting with the American Society of Metals was held at the Engineers' Club on Monday, April 17th. Mr. L. C. Keading, Engineer of The Standard Oil Company, recently returned from Bahrein, Arabia, gave a coffee talk accompanied by moving pictures, entitled "Impressions of Arabia."

Mr. W. M. Cohn, Consulting Physicist, gave a lecture accompanied by projected pictures, on "Spectro-Graphic and X-Ray Analysis of Metals as Applied to Modern Industry."

Mr. C. W. Smith of The Linde Air Products Company showed a moving picture of "The Union Melt Process for Single Pass Welding."

SAN JOAQUIN VALLEY

The first of a planned series to be held jointly on the Campus of the Kern County Junior College in Bakersfield and that of the Taft Junior College in Taft, was held on Friday, March 24th, in Bakersfield. The Section enjoyed the greatest turn-out this year and had the pleasure of 110 guests present which speaks well for their appreciation of the program presented.

Previous to the showing of the American Rolling Mills Co. film, Mr. J. Wilson, representative of the Company, gave a very interesting talk on the methods used by the Company in its manufacture of various steel products. The Union Oil Co. film on Air Travel was well received and most enlightening to every one present as it presented facts of modern air travel emphasizing safety and comfort.

Following this program the Air Reduction Sales Company of Los Angeles put on the first demonstration of "Flame Hardening" to be shown in Kern County and it proved to be intensely interesting to the many shop owners and department heads present. The demonstration was under the able direction of Mr. "Bud" Emory and Mr. Guy D. Atmore of the Air Reduction Sales Company.

WASHINGTON, D. C.

The sixth regular meeting of the Section was held on Tuesday, March 28th. President H. C. Boardman, Research Engineer, Chicago Bridge and Iron Company, addressed the Section, on the subject "Large Welded Tanks of Cylindrical, Spherical and Spheroidal Shapes." This lecture proved to be of particular interest and was thoroughly enjoyed by every one present.

WESTERN NEW YORK

The March 16th meeting was a successful meeting with approximately 65 people present. The speaker was Mr. E. W. P. Smith, Consulting Engineer, The Lincoln Electric Company. His subject was "Factors in Low Cost Manufacture of Welded Products."

WICHITA

Mr. Orville T. Barnett, Metallurgist for Black, Sivalls & Bryson, Inc., spoke before the Wichita Section on March 31st. Mr. Barnett's subject was "X-Ray as a Production Tool in Modern Pressure Vessel Manufacture."

Preceding the meeting the Executive Committee and members had their usual round table dinner party, which was well attended.

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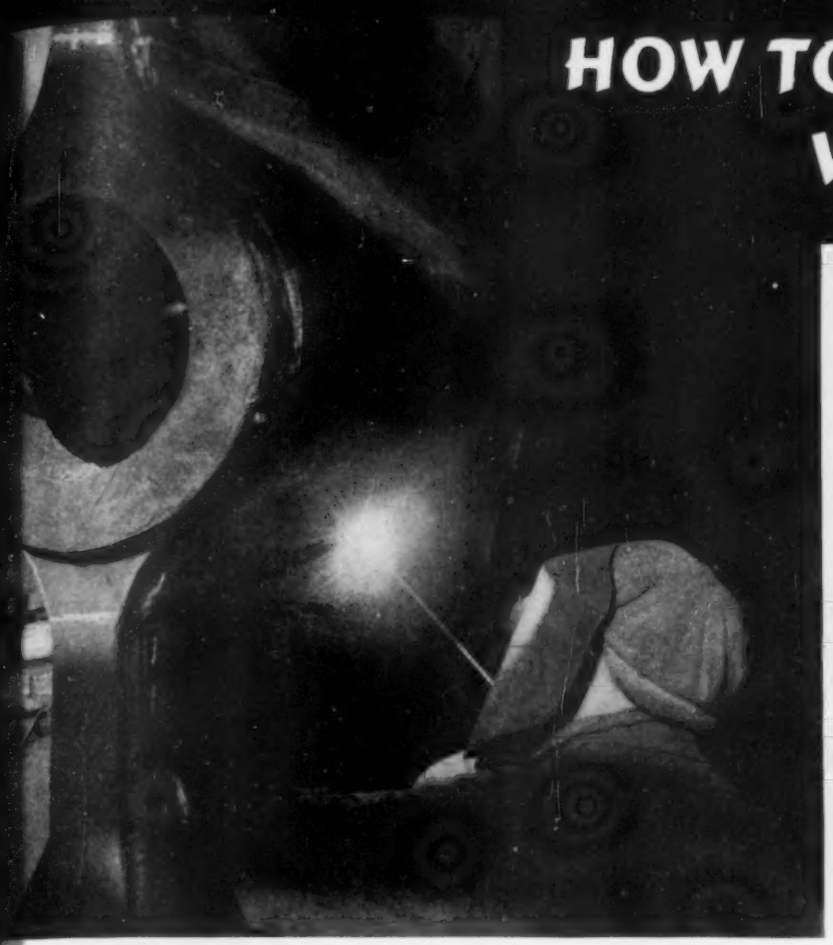
IMPORTANT CHANGES ANNOUNCED IN METHODS OF PUBLISHING A. S. T. M. STANDARDS

Important modifications are to be made, according to an announcement from the Headquarters of the American Society for Testing Materials, in the methods of publishing the Society's standard specifications and tests. These changes are to become effective November 1939. The major change is to combine the Book of Standards (issued triennially) and the Book of Tentative Standards (issued annually). These changes which also embody numerous advantages are necessary because of the great growth of A. S. T. M. standardization work.

All of the 870 A. S. T. M. standards are in widespread use in many branches of industry and commerce. Each is available, and will continue to be in separate pamphlet form, and the standards have been issued in triennially published books of standards with an annual volume giving the so-called tentative standards and tests.

The new method of publication will be to issue the standards and tentative standards collectively in one triennial publication, divided into three parts: Part I, Metals; Part II, Non-Metallic Materials—Constructional; and Part III, Non-Metallic Materials—General. Publication of new and revised tentative standards in the annual *Proceedings*, Part I, will be discontinued; the *Proceedings* including both committee reports and papers (about 1300 pages double-column format) will be bound in one volume. The publication of the annual Book of Tentative Standards will be discontinued entirely. (The November 1938, edition is thus the last one to be issued.)

HOW TO REDUCE YOUR WELDING COSTS



From coast to coast, in plants fabricating welded structures of every description, Murex electrodes are helping to reduce welding costs. The reasons why are many. In one plant high burn-off rate may prove an advantage. In another, rapid deposition, or lack of spatter and smoothness of deposit may do the trick.

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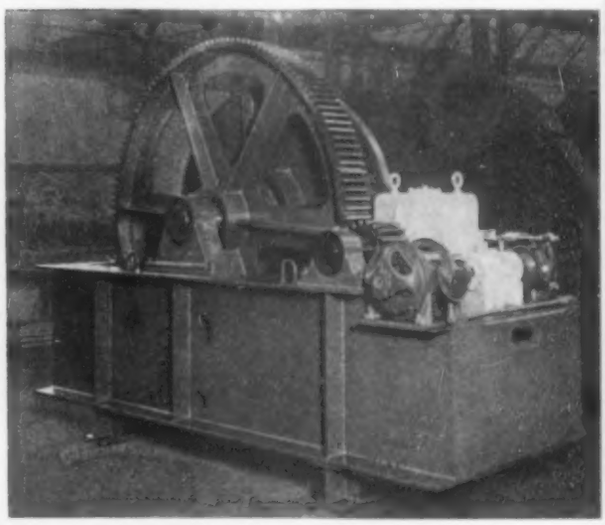
...ine work, vertical and overhead welding goes easily and quickly with Murex Vertex (reverse ...ity) or Genex (straight polarity). *Photo courtesy Ira S. Bushey & Sons Co., Inc., Brooklyn, N. Y.*

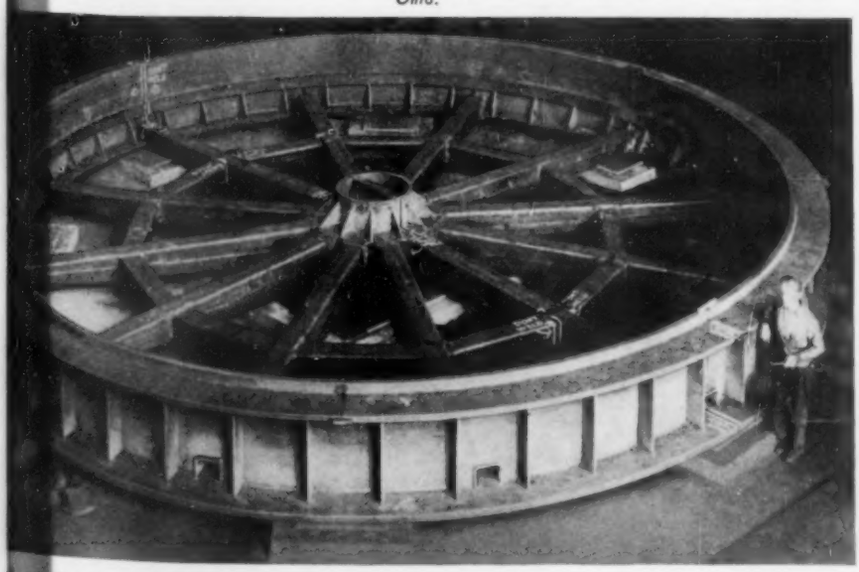
We've a handy, pocket-size pamphlet giving applications and properties of each of the twenty electrodes in the Murex line. Send for your copy.

...0 lbs. of Murex Type F were required for ...welded, staybolted, jacketed still, weighing ... *Photo courtesy John Nooter Boiler Works ..., Mo.*

3 High speed deposition of consistently sound metal saves time and money in production of the new Lorain 79 Shovel with welded frame and boom. *Photo courtesy The Thew Shovel Company, Lorain, Ohio.*



5 Economy of welding special machinery such as this sluice gate hoist (one of four for a Govt. flood control project) in which even the gears are fabricated is promoted still further by time-saving Murex Electrodes. *Photo courtesy Lakeside Bridge & Steel Co., Milwaukee, Wis.*



...ree-flowing Murex downhand electrodes speeded welding on this 96,200 lb. pot chuck, 33 ft. 7 in. in ...meter. *Photo courtesy the fabricators, Lukenweld, Inc., Coatesville, Pa.*

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George, Stanley L. (D), Route 1, Box 74 B, Irondale, Ala.
Neel, A. O. (C), General Delivery, Gardendale, Ala.
Swader, C. W. (B), Chas. C. Steward Mach. Co., Birmingham, Ala.

BOSTON

Boyle, Richard A. (D), 76 Lincoln Ave., Saugus, Mass.
English, Richard C. (C), 123 Landseer St., West Roxbury, Mass.

CHATTANOOGA

Franer, Frank (C), Chattanooga Boiler & Tank Co., 1030 E. Main St., Chattanooga, Tenn.
Glenn, Mark Twain (C), 2420 Oak St., Chattanooga, Tenn.
McConnell, Ray (C), Combustion Eng. Co., 1032 W. Main St., Chattanooga, Tenn.
Parry, S. R. (C), Combustion Eng. Co., 1032 W. Main St., Chattanooga, Tenn.
Richardson, A. C. (C), Combustion Eng. Co., 1032 W. Main St., Chattanooga, Tenn.
Roberts, W. M. (C), Combustion Eng. Co., 1032 W. Main St., Chattanooga, Tenn.
Smith, Hope (C), Combustion Eng. Co., 1032 W. Main St., Chattanooga, Tenn.
Wall, Marion P. (B), Combustion Engrg. Co., 1032 W. Main St., Chattanooga Tenn.

CHICAGO

Andersen, H. M. (B), 2209 S. 61st Court, Cicero, Ill.
Boley, Frederick W. (C), 7244 Coles Ave., Chicago, Ill.
Hurley, Wallace J. (D), 1638 N. Linder Ave., Chicago, Ill.

CINCINNATI

Beiersdorfer, Louis W. (D), 58 Glenwood Ave., Cincinnati, Ohio.
Biery, Albert A. (D), 428 S. Miami Ave., Cleves, Ohio.
Burdge, Oscar B. (D), Washington Ave., North Bend, Ohio.
Edwards, Oliver H. (C), Cincinnati Butcher's Supply Co., 2145 Central Parkway, Cincinnati, Ohio.
Wilhelm, Frank J. (C), The Dayton Fabricated Steel Co., 1300 E. Monument, Dayton, Ohio.

CLEVELAND

Austin, John B. (C), 1021 Nela View Road, Cleveland Heights, Ohio.
Fay, Z. John (B), 2148 Brown Road, Lakewood, Ohio.
Jennings, Wm. L. (C), 1076 E. 171st St., Cleveland, Ohio.
Lewis, James T. (C), Lewis Welding & Engrg. Co., 881 Addison Rd., N. E., Cleveland, Ohio.

CONNECTICUT

Perry, Bernard H. (B), 125 Camp St., New Britain, Conn.

DETROIT

Stover, C. R. (B), 337 George St., Trenton, Mich.

GEORGIA

Shearouse, James D. (B), Sou Iron & Equip. Co., Atlanta, Ga.
Stephens, De Witt (D), 790 Ponce de Leon Pl., Atlanta, Ga.

HAWAII

Foley, W. J. (B), 2729 Irving Ave., S., Minneapolis, Minn. (temp. add.)
Jones, Edward J. (C), 1631 Poloma St., Honolulu, T. H.

INDIANAPOLIS

Morris, F. H. (B), R. B. M. Mfg. Co., Logansport, Ind.

LOS ANGELES

Laszloffy, A., Jr. (D), 1113½ Manzanita St., Los Angeles, Calif.
Ross, Jack D. (D), 1324 N. Lima St., Burbank, Calif.

MARYLAND

Schuler, George A. (D), 16 N. Highland Ave., Sparrow's Point, Md.

MILWAUKEE

Cooper, Gerald A. (D), 2435 W. Wisconsin Ave., Apt. 205, Milwaukee, Wis.

NEW YORK

Buonasera, Albert (B), Colonial Welding Co., 108–53 Roosevelt Ave., Corona, L. I.
McKeel, Gerald M. (D), & Metropolitan Hospital, Dormitory No. 1, Welfare Island, N. Y.
Paulson, Frank C. (C), 89 Glenwood Road, Ridgewood, N. J.
Wagner, Gerhard (C), 233 Broadway, New York, N. Y.

NORTHERN NEW YORK

Reed, Walter C. (C), General Electric Co., Pittsfield, Mass.

WESTERN NEW YORK

Fiero, Austin (D), 213 Washington Ave., Batavia, N. Y.
Glover, Walter G. (D), 25 Vine St., Batavia, N. Y.
Markham, Robert (D), 25 Liberty St., Arcade, N. Y.

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Gander, Aksel (D), 137 Bedford St., S. E., Minneapolis, Minn.
Janovec, Ed. (D), 64 Bedford St., S. E., Minneapolis, Minn.
Knudson, M. N. (B), Maintenance Supt., Minnesota & Ontario Paper Co., International Falls, Minn.

OMAHA

Reiff, Stanley G. (C), 934 Redick Tower, Omaha, Nebr.

PEORIA

Troike, Otto (D), 508 N. Glen Oak Ave., Peoria, Ill.

PHILADELPHIA

Colosi, Anthony (D), 2722 S. 8th St., Philadelphia, Pa.
MacKinney, John J. (C), 5419 Germantown Ave., Philadelphia, Pa.
Russell, Roy (D), 249 Clifton Ave., Sharon Hill, Pa.
Swan, Harry S. (C), John A. Roebling's Sons Co., Trenton, N. J.
Willis, John G. (C), 325 Morris St., Woodbury, N. J.

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Satterlee, W. F. (B), % Hunter Steel Co., Neville Island, Pa.

ROCHESTER

Phaff, James (D), 937 Genesee St., Rochester, N. Y.

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Bland, George O. (C), Hill Equip. & Eng. Co., 3431 Chouteau Ave., St. Louis, Mo.
Gill, Harry C. (B), Missouri Boiler & Sheet Iron Wks., 908 S. 23rd St., St. Louis, Mo.
Ritchie, R. W. (B), American Bureau of Shipping, 1435 Boatmens Bank Bldg., St. Louis, Mo.

SAN FRANCISCO

Smith, Art (F), 2237 A—62nd Ave., San Francisco, Calif.

SOUTH TEXAS

Jacks, C. G. (C), The Linde Air Products Co., 6119 Harrisburg Blvd., Houston, Texas.
McCormick, K. A. (B), Wyatt Metal & Boiler Wks., P. O. Box 3052, Houston, Texas.

TULSA

Barnes, I. H. (D), Box No. 1679, Tulsa, Okla.
Price, H. D. (D), 1736½ So. Quannah, Tulsa, Okla.

WASHINGTON, D. C.

Biggs, William E. (C), 4000 Cathedral Ave., N. W., Washington, D. C.

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Cardwell, H. W., Jr. (B), Allsteel Prods. Mfg. Co., 801 S. Wichita St., Wichita, Kans.
Melzarek, C. A. (C), 412 S. Bluff, Wichita, Kans.

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Flask, Joseph (B), Heltzel Steel Form & Iron Co., Warren, Ohio.
Heltzel, C. J. (B), Heltzel Steel Form & Iron Co., Warren, Ohio.
Heltzel, J. N. (B), Heltzel Steel Form & Iron Co., Warren, Ohio.
O'Connor, Michael (B), Heltzel Steel Form & Iron Co., Warren, Ohio.
Murray, J. J. (B), Heltzel Steel Form & Iron Co., Warren, Ohio.
Wolbert, Charles (B), Heltzel Steel Form & Iron Co., Warren, Ohio.

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Colby, Fred C. (D), 217 College Ave., Waterville, Maine.

Curtiss, Joseph C. (D), 1924 Berkshire Pl., Toledo, Ohio.

Gallagher, C. S. (B), Bettendorf Co., Bettendorf, Iowa.

Harris, Hugh H. (C), 2216—5th Ave., Moline, Ill.

Hurlbutt, Robert H. (C), U. S. Engineers, Clock Tower Bldg., Rock Island, Ill.

Meyers, Fred H. (D), Texhoma, Okla.

Miklosi, Dr. Ing. Cornelius (C), Piata Coronim II., No. 11, Timisoara, Roumania.

Monsarrat, Nicholas (C), Pantex Pressing Mach., Inc., Central Falls, R. I.

Stocking, Kenneth O. (C), U. S. Engineer Office, Clock Tower Bldg., Rock Island, Ill.

Wentworth, Philip S. (D), 105 Heflin Court, San Antonio, Texas.

TINY METAL GLOBULES IMPROVE X-RAY PHOTOGRAPHS

Metal shot, some so fine they float on water, play an important part in the making of sharply defined X-ray photographs of irregular metal objects in the Schenectady Works Laboratory of the General Electric Company. Should an X-ray photograph of a monkey wrench be wanted, for example, the technicians would pour tiny shot over and about it—spherical particles of copper or steel so small that 10,000,000 of them nestle together in a mere cubic inch of space. The photograph then obtained has all the edges of the parts of the wrench sharply outlined. Had a similar photograph been made with the wrench simply resting on the X-ray negative holder in the air, the resulting picture would have very fuzzy or blurred edges outlining the tool.

The explanation, according to C. D. Moriarty of the G-E Works Laboratory, is that there is such an emphatic difference in the absorption of X-rays by air and by metals that the part of the X-ray negative not in back of the metal is necessarily over-exposed, with the result that the exposure "spills over" and blurs the edges of the object. Again, when the object being examined has some sections emphatically thinner than other parts, there is a similar fuzziness of edges. One way of overcoming this difficulty in the past was to use a film of low contrast value, with special filtering screens, and requiring relatively long exposures. Even so, the X-ray pictures, or radiographs, would lose considerable detail and contrast. Another way was to immerse the article under examination in a solution of lead acetate or similar compound which is much more opaque to X-rays than is air. Such liquids improved the sharpness and contrast of the radiographs, but they still left room for improvement since none of the liquids used was of opaqueness approximating the metal. A third method has been by building up a block of special, lead-bearing putty around the object. Nonuniformity of the putty, however, has been a handicap with such technique.

Now, utilizing metal shot, an almost unlimited range of absorption coefficients is obtainable, depending on the metal used; and the uniform packing of the fine spherical particles assures homogeneity. Technicians can use the short-exposure films with intensifying screens and obtain greater contrast and detail in the radiograph.

XIII. INTERNATIONAL ACETYLENE CONGRESS

Since the Commission Permanente Internationale delayed the Congress to Oct. 2-6, 1939, the last date for receipt of papers, reports and films has been shifted to June 15th.

Those intending to present papers, reports, and films should notify the office of the Congress at Bennigsenstrasse 25, Berlin-Friedenau, Germany as soon as possible. Two typewritten copies of each report in one of four languages (German, English, French and Italian) should reach the office of the Congress by June 15, 1939. Films to be presented before the Congress also should reach the office by June 15th.

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* LONGER LIFE

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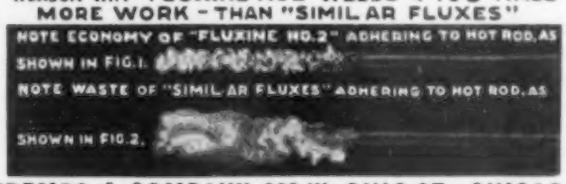
REASON WHY- FLUXINE Nº2 WELDS 4 TO 5 TIMES MORE WORK - THAN "SIMIL AR FLUXES"


NOTE ECONOMY OF "FLUXINE NO.2" ADHERING TO HOT ROD, AS SHOWN IN FIG.1.
NOTE WASTE OF "SIMIL AR FLUXES" ADHERING TO HOT ROD, AS SHOWN IN FIG.2.

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